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ABSTRACT

This document draws on both research and practical experience in order to develop a technology system to serve the K-12 community for the next 5 to 10 years. The study offers its design based on projections of where technological advances will intersect with the evolution of the school system. Sections include: (1) "Introduction"; (2) "Technology and Society"; (3) "Principles of Learning"; (4) "The Impact of Technology on Schools"; (5) "Linking Education Reforms and Technology"; (6) "Creating Expanded Learning Environments"; (7) "Instructional Technology Applications in the Classroom"; (8) "Curriculum and Technology"; (9) "Administrative Technology Applications"; (10) "Technological Advances"; and (11) "Envisioning the Future: America's 21st Century Schools." Discussion focuses on technology's role in creating a society of lifelong learners as well as creating schools which tailor education to different developmental stages and learning approaches, nurture student-centered knowledge, and reach beyond their own walls for novel educational partnerships. The technology itself is also covered, along with suggestions for its use with specific classroom situations, age groups, and subject disciplines. (Contains 204 references.) (BEW)

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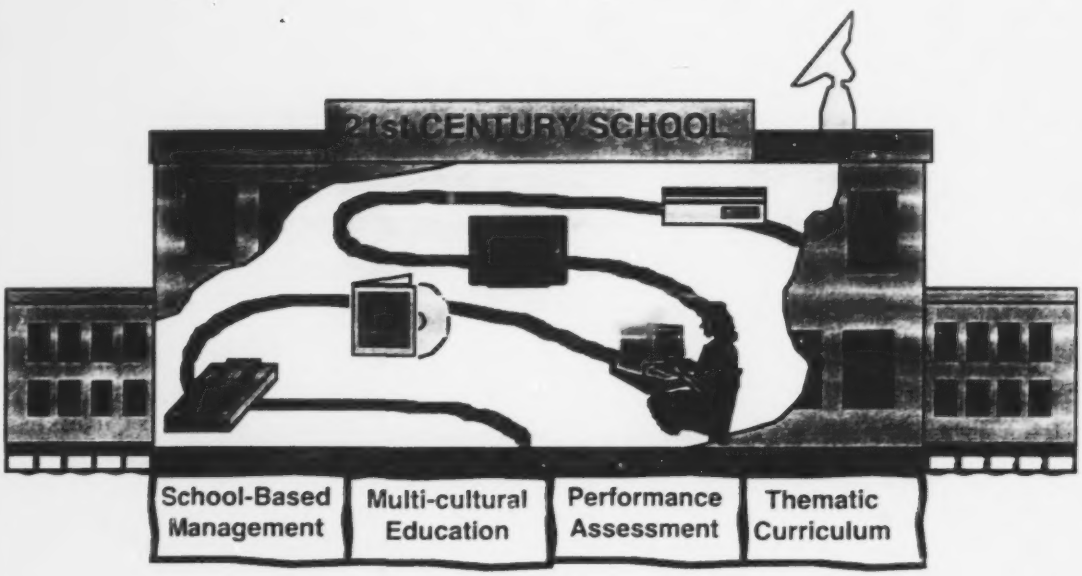
America's 21st Century School:

Linking Education Reform and Technology



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EXECUTIVE SUMMARY

This document represents a survey of research and practical experience. It addresses how teaching and learning is changing as we prepare to enter the 21st century and how technology can be used as a tool to manage and implement those changes. As we proceed with this study and begin to design a technology system to serve the K-12 community for the next five-to-ten years, we must project where technology advances will intersect with the evolution of the school system in order to create an effective design. This report represents our image of that target education system. While not all of the ideas and concepts portrayed in this paper will be adopted, our design must be tailored to support every option that a school system in America may choose to implement.

Technology and Society

We are entering an era of human development where learning is the primary survival skill. Change is a pervasive fact of life. Most workers have jobs that did not exist when they were born and will change careers three times during the course of their work lives. Our education system must meet this challenge of preparing people for constant change if we are to continue to thrive as a society. Key issues that we must face include the need for life-long learners, the use of technology as a catalyst for bringing about change, and the need to establish a "critical mass" so that technology is as widely infused in our schools as it is in our economy.

Principles of Learning

The growing field of cognitive research has given us a powerful new understanding of how the mind grows and learns at various stages in human development. We must use technology to restructure education to become more effective, leveraging what we know about how people of all ages acquire knowledge. We have discovered that all learners process information in distinctly personal ways; we must incorporate technology as a tool to personalize education in order to maximize individual strengths. We must create self-sufficient problem solvers in student-centered, cooperative learning environments that address the following unique needs of learners at each developmental stage:

- multi-sensory processing (elementary)
- demonstration of knowledge (intermediate)
- need for self-exploration (middle)
- integration of concepts across subject areas (secondary)
- life-long learning (adult)

The Impact of Technology on Schools

Technology will transform our schools just as it is changing all other aspects of our world. The widespread implementation of technology into the educational system will allow learning to occur in new ways (voice, video, data) and will empower students to control their own learning. Teachers will view learning as an active, creative, socially interactive process that gives rise to the creation of student-centered knowledge, rather that the transfer of information intact. Managers will be accountable for decision-making since technology tools will be available to support this process.

Linking Education Reforms and Technology

Technology can help us reach ambitious reform goals by providing the means to offer integrative/interdisciplinary education, equal learning opportunities, individualized programs, and performance-based assessment. The application of technology will also decentralize decision making by capturing and distributing essential information throughout the school, district, and state.

Creating Expanded Learning Environments

To meet the need to develop and support life-long learners, we must reach beyond the school house walls. These expanded learning environments take the forms of 1) global classrooms where telecommunication and advanced technologies make it possible for students to collaborate and share resources, 2) library and media information centers that allow students to identify and apply information from a wealth of resources, and 3) alliances and collaborations with higher education and business.

Instructional Technology Application with the Classroom

Technology can provide powerful tools to assist teachers in the classroom. Instructional technology in America's 21st century schools will allow teachers to create lesson plans that integrate process skills, content objectives, and technology competencies. It will provide opportunities for students to solve situational problems, enhance the quality of their thinking, and maintain an awareness of world events.

Administrative Technology Application

Education reform is also putting new demands on all levels of school management. The infusion of technology will allow access to information for decision-making by teachers and administrators and will assist the professional staff in addressing school reform. It will increase communication at all levels and provide for the aggregation of school data statewide.

Curriculum and Technology

Technology must not only be integrated into new curricula, but it must also become a tool to help develop and disseminate new curriculum approaches and manage the instructional process. Technology can be used to reframe the curricula in order to accommodate reform aimed at promoting process-oriented, skill-based outcome education. It will serve to align curriculum, instructional resources, assessment, and student information. Using technology, teachers will become facilitators or coaches in the instructional process rather than disseminators of information. Technology incorporated into the curriculum will cause both teachers and students to define and acquire technology competencies.

Technological Advances

Rapid changes in technology are a fact of modern life. Many technology changes will impact us over the next five-to-ten years. Our study must be designed to incorporate the following changes as they become practical and needed:

- rapid changes in processing power, storage capacity and communication bandwidth
- dramatic developments in the digitization of telecommunication
- increased availability and recognized usefulness of laserdiscs and CD-ROM technology products

- distance learning
- universal access to technology for students and teachers
- achievement of "critical mass"

Conclusion

In envisioning the future for America's schools in the 21st century, technology will serve as a catalyst to foster and support far-reaching changes in how we define teaching, learning, and "school" itself. Public education centers of the 21st century will garner broad-based support from the community-at-large by providing lifelong learning opportunities to all community members and fostering interagency collaboration among community service providers.

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1. INTRODUCTION

Our overall goal is to develop an education technology master plan for America that will support teaching, learning, and management for the 21st century. Current research encompasses a myriad of educational structures, including classrooms, schools, school districts, community, home, libraries, higher education, museums and many other learning environments. The information in this document represents a synthesis of: (1) experiences of educators with various information technologies; (2) national research studies and reports; (3) discussions with leading education technologies vendors; and (4) existing studies and reports written by education organizations about their present and future needs for education technology resources.

Although technical aspects of the study are focused primarily on providing an open system and multi-vendor technology infrastructure, the overall study is curriculum- and instruction-based. It will be further adapted using the outcomes of the common core of learning. The study will also assist educational organizations by providing standards for the selection of workstations, peripherals and network components, as well as specifications for communications, tool-based and administrative software.

In general, this document provides a comprehensive perspective on technology in education and answers the fundamental question of "What teaching, learning, and management activities will the study be designed to support?" It is important to note that technology alone will not revitalize our curriculum approaches and methodologies, but rather we must begin planning for the integration of revised curriculum with the effective use of technology. Lastly, technology will not transform schools, but rather schools will have to be comprehensively and systematically restructured in order to make effective use of technology.

2. TECHNOLOGY AND SOCIETY

"In times of change, learners inherit the earth, while the learned find themselves beautifully equipped to deal with a world that no longer exists."

- Eric Hoffer

The advent of the information age signals an era of rapid change where lifelong learning is no longer an option, but a critical survival skill (Thornburg, 1991). In the recent past, people acquired a set of skills and would apply them throughout their work lives. This is no longer the case.

> "Today, in industrial countries, most people are doing jobs that did not exist when they were born. The most important skill in determining a person's life pattern has already become the ability to learn new skills, to take in new concepts, to assess new situations, to deal with the unexpected. This will become increasingly true in the future: The competitive ability is the ability to learn" (Papert, 1993).

Many of the societal changes that have occurred over the last decade can be directly attributable to technology. It has transformed business, worldwide communications, and recreation -- we can do our banking 24 hours a day; observe, first-hand, the collapse of the Berlin Wall, destruction of the rain forests and the Persian Gulf War; and bring VCR movies into our homes. Technology has created a world where change is a constant and constant learning is the change. While every critical aspect of our country's economic and social infrastructure has incorporated powerful technology tools, most schools in America remain dangerously cloistered in the 1950s with outdated curricula, methodologies and technology.

> "In the first part of this century, we adopted the principal of mass-producing low-quality education to create a low-skilled work force for mass-production industry. Building on this principle our education and business systems became very tightly linked, evolving into a single system that brilliantly capitalized on our advantages and enabled us to create the most powerful economy and the largest middle class the world has ever seen. The education system, modeled on industrial organization, was crafted to supply the work force that the industrial economy needed. America's systems of school organization and industrial organization were beautifully matched, each highly dependent on the other for its success, each the envy of the world" (Marshall and Tucker, 1992).

Our educational system must once again be "beautifully matched" with our information-age, service-oriented, ever-changing economy, providing workers who can access, analyze and communicate information. Schools must now, as in the past, provide a workforce well-suited to meet economic demands. They must adopt models of teaching, learning, and management supported by technology tools to create the lifelong learners needed to maintain our country's social structure and economic growth in the 21st century.

2.1 Technology and Societal Change

It often takes decades after the appearance of a new technology for society to adopt it and properly exploit its potential. The post-World War II suburbanization wave

followed by some fifty years the appearance of the automobile. Fax technology was invented in 1902, yet took off only after the establishment of the Group 3 technical standard in 1980 and the availability of cheap machines in the mid-to-late 1980s combined with the presence of a universal telecommunications infrastructure. Videodiscs were developed in the 1960s, but their widespread adoption in schools occurred only at the end of the 1980s.

For technologies to take root, several factors must converge. A critical mass must develop in the number of users, user ease and infrastructure. Appropriate applications must be developed and applied. And changes in social and work organization must be made. Only then does what Zuboff calls "informating" take place and allow society to exploit the potential of the new technology.

The recent rash of mergers in the telecommunications sector augur vast changes emerging in society. Branches of the "information superhighway" are in place, the National Information Infrastructure (NII) is being conceptualized as a public-private partnership, and Washington now talks of the III, the International Information Infrastructure. The Global Village is here. But what factors must converge to produce or enable positive improvements in work, society and schooling in America?

2.2 Technology and Productivity

Through the 1980s, despite the ever-widening computerization of American business, the press was filled with reports that few productivity gains were being realized. Explained McKinsey and Co. technology and systems expert, Thomas D. Steiner, "We're really still at the beginning of this computer age. There is a fair amount of experimentation and a lot of horror stories. We're convinced that technology will reduce costs. It just takes a long, long time to get these systems working properly" (*New York Times*, June 29, 1987).

In 1993, after four years of economic recession, industry restructuring, and the growth of an ever-expanding computer networks and communications infrastructure, press accounts report that the computer revolution has taken hold and widespread productivity gains had ensued. A late 1992 study by the McKinsey Global Institute found that the United States commanded a significant lead over Europe and Japan in productivity, owing mostly to the US lead in the services sector. In some US sectors, like banking, its computer and communications networks have become the common infrastructure.

What created the difference from the mid-1980s? Critical mass has been reached in the number of users, users' familiarity with computers, and communications. Throughout the service sectors, the use of local- and wide-area networks exploded. Computers and communications have converged, and the adoption of graphical user interfaces like Macintosh and Windows have made the learning curve easier and expanded exponentially the number of productive users.

Headlines about the "virtual corporation" signal this change. It should be stressed that "virtual corporations" are not synonymous with "virtual reality;" instead they are real corporations that are becoming leaner, more engaged in core activity and are outsourcing much of their work to other companies or to consultants. British management expert Charles Handy in his book "The Age of Unreason" (Harvard University Press, 1989) calls this the "shamrock organization." It is in this sense that the "virtual school" may emerge, functioning as Handy says, "a shamrock with a core activity and everything else contracted out or done part time by a flexible labor force.

The core activity would be primarily one of educational manager, devising an appropriate educational program for each child and arranging for its delivery."

K-12 education is in much the same place today as the service industry of the mid-1980s. Despite great capabilities available in schools today to single desktop machines with associated communication links, critical mass is nowhere in sight. Schools and school districts are "spotted" with technology-using teacher "pioneers", but universal utilization and its associated productivity gains remain distant and elusive. The Wall Street Journal calls the new Stuyvesant High School in New York City a "computer nerd's dream but an educator's quandary" (WSJ, November 23, 1992). The Journal also complains that the technology fails to "cut costs or improve productivity."

2.3 Skills for the Information Age

The purpose of schools today is to help students gain the skills, aptitudes and attitudes to be productive workers and citizens in the global economy of the 21st century. The "new basic skills" go way beyond those that most adults acquired when they were in school. In contrast to the mainframes and communication technologies of the past two decades which supported hierarchical and centralized work and social organization, today's new technologies, says George Gilder,

> "allow for the evolution of peer networks. Managers, workers, and customers interact directly; with telecomputers, they exchange, manipulate, store, and display not only words and numbers but also a variety of image-based information, from three-dimensional simulations to high-definition films. The technology will ultimately change what we mean by management, customers, products, ownership -- even nationality" (1991).

The 1991 report, "What Work Requires of Schools," by the Secretary's Commission on Achieving Necessary Skills (SCANS) and published by the US Department of Labor, defines a framework that can serve as the foundation for the establishment of education goals and objectives in the Nation. Future citizens, whether they work on the shop floor or in the executive suite, will need to master the following competencies and foundations skills:

COMPETENCIES:

- *resources* -- identifies, organizes, plans, and allocates resources
- *interpersonal* -- works with others
- *information* -- acquires and uses information
- *systems* -- understands complex inter-relationships
- *technology* -- works with a variety of technologies

A THREE-PART FOUNDATION:

- *basic skills* -- reads, writes, performs arithmetic and mathematical operations, listens and speaks
- *thinking skills* -- thinks creatively, makes decisions, solves problems, visualizes, knows how to learn and reasons
- *personal qualities* -- displays responsibility, self-esteem, sociability, self-management, integrity and honesty

James Mecklenburger, the executive director of the Global Village Schools Institute, shortens this list to the seven Cs. Mecklenburger asserts that "an educated person means becoming a person adept at comprehension, creativity, calculation, collaboration, competition, contribution, and communication."

In "The Twenty-First Century School: Linking Education reform With the Effective Use of Technology" (*EDU magazine*, Spring/Summer, 1992), John Phillipo, Executive Director of the Massachusetts-based Center for Educational Leadership and Technology, writes:

> "The 'new basic skills' for the twenty-first century will require students to have the ability to access, analyze, and communicate information effectively. They must be empowered through the use of technology to create their own knowledge. As information changes and increases in volume, students must be able to think more critically, communicate more creatively, and problem solve more analytically. These information processing skills will enable our students to assume a productive role in an information age that is integral to our global economy. By the year 2000, the demand for knowledge will increase tenfold. Without widespread, systematic integration of the 'new basic skills' into curricula, the need for knowledge workers will be left unmet and our economic position in the world economy will be uncertain."

Various degrees of implementation of the Global Village School (GVS) can be observed in different forms of progression and implementation in today's schools. Many schools have begun the "re-organization" process as evidenced by the development of site-base management teams and their focus to establish ties more effectively among teachers, parents, students and the community. Curriculum is being revised and refocused to include a more interdisciplinary, thematic approach to instruction. Alternative assessment practices have already begun, triggered by new competencies that serve as benchmarks at grades four, eight and twelve. Redirection towards outcomes-based education has also taken place. Effective uses of technology are currently found in many areas, across all grade levels. Educational leaders must recognize those examples that have been successful and create models for similar technology integration plans. Lastly, learning environments are being altered to reflect the changing role of teacher as being "sole-source" providers of knowledge to one where teachers function as facilitators of learning. It is time to enact all the recommended changes simultaneously, in an organized, systemic approach to make the GVS become a reality.

2.4 Global Village Schools

Marshall McLuhan coined the phrase "Global Village" three decades ago to explain the impact of the information age on society. Education in a Global Village School

(GVS) would be appropriate for both today's and tomorrow's world. According to Mecklenburger, "a GVS will be concerned with round-the-clock learning. A school building will not define the school; a building may be the 'headquarters' of a community of learners but not the sole location. Electronically, through voice mail and various networking schemes, there are many ways even today that home, school and other institutions near and far can be intimately connected..." (Mecklenburger, Fall 1993). This is a vision not unlike Charles Handy's concept of schools as a 21st century "shamrock" organization, leaner and more core, outsourcing many of its tasks to other educational service providers.

Changing schooling requires the changing of all elements of school practice and organization simultaneously, argues Robert Pearlman in "Designing the New American Schools" (*Communications of the ACM*, May, 1993). Pearlman identifies these as critical elements of change within schools.

- *School organization* -- Re-organization of large schools and their isolated classrooms into smaller cluster communities that provide more personal environments for children and self-managing work teams for teachers.
- *Curriculum* -- Replacement of teacher-talk, workbooks and make-work academics by meaningful and authentic short- and long-term project work by students.
- *Assessment and accountability* -- Establishment of a personal growth system to assist students, parents and teachers to set goals, plan, monitor and assess a student's evolving performance through real products, presentations and exhibitions of their work and a shift of school accountability from basic-skill multiple-choice tests to new performance-based tests and other high-performance indicators.
- *Technology* -- Supporting a change in learning and teaching toward project work, technology should be made ubiquitous in the school building and community to provide students and teachers with the tools and local infrastructure to do their work and to communicate and collaborate with one another and with similar-minded collaborators throughout the world.
- *Learning environments* -- Re-design of learning environments in schools where students and teachers are workers in educational workplaces, with spaces that are workrooms, work areas, seminar rooms and conference rooms.

2.5 Technology's Role in 21st Century Schools

All states will need to adopt policies and develop the infrastructure that enables schools and school districts to leverage their investments in the new technologies.

In the first decade of the microcomputer revolution, there was a considerable "transfer" problem in bringing technology into schools. Most hardware and software applications were first developed for the business environment and then applied to the K-12 environment. In this first phase, schools often had state-of-the-art equipment, though in small numbers.

But by the early 1990s, exemplary models of technology use and integration are increasing exponentially. For example:

- Students in the global lab project, headquartered in Cambridge, MA, which links 101 schools in 27 states and 17 countries, establish environmental

monitoring stations to study climate change, monitor pollutants and measure radiation. Schools then share the data over the network with each other and with scientists to gain a global perspective on environmental problems.

- Over 14,000 schools watch the daily news program, CNN Newsroom, and 10,000 schools receive Whittle's Channel One. Cable in the Classroom provides educational use of cable programs throughout the United States.
- 6,000 schools receive Distance Learning courses via satellite. The Massachusetts Corporation for Educational Telecommunications (MCET) delivers curriculum modules that support teaching to 37 states via satellite, Picture Tel, videodisc and videotape. Students take Electronic Field Trips to Berlin, China and elsewhere.

Using technologies such as computers, CD-ROMs, videodiscs, phones, cable, broadcast, satellite, local-area networks and wide-area "Internetworking", America's students and teachers in 21st century schools will be able to do their work, access information, communicate via electronic mail with each other and with mentors, engage in collaboration and student project-oriented work, take electronic field trips and receive and use courses from any number of educational service providers.

2.6 Creating 21st Century Schools and Supporting Technology Infrastructures

But knowing how to apply the new technologies in schools is only the first part of the puzzle. Developing a critical mass, locally and statewide, through policy and investment and making the appropriate changes in school organization are the next hurdles for the various states.

Schools lack critical mass. The first person with a telephone gets little productive use if his/her neighbors and family are without phones; or the first person with a car in a remote region realizes little benefit until others also acquire them and local society and government build roads for the local infrastructure. So, too, in schools, things don't take off until most teachers and children are using technology to do their work and they can communicate with each other and with parents and community-based mentors as easily as "pioneer" technology-using teachers and students can today share data and reflections with counterparts in Moscow on the Global Lab project.

Besides a lack of physical infrastructure in schools and the state in terms of local- and wide-area network developments, another serious problem is that schools are filled with outmoded equipment. According to Quality Education Data (QED), fewer than 30% of the computer equipment in schools today can support graphical user interfaces (GUI) such as Windows or Macintosh icons. These GUI interfaces are critical to today's applications, whether in the creation of multi-media documents or in "Internetworking" around the globe.

In order to begin the process of designing America's 21st century schools, it requires developing the policies and determining the level of investment that will establish critical mass throughout the school, district and state. The establishment of critical mass will encourage local investment in new technologies and state-of-the-art equipment in schools and communities. More importantly, it will assist America's schools in the process of envisioning, reorganizing and redesigning themselves into 21st century educational facilities.

3. PRINCIPLES OF LEARNING

"Real learning does not happen until students are brought into relationship with the teacher, with each other, and with the subject. We cannot learn deeply and well until a community of learning is created in the classroom."

- Parker J. Palmer, 1983

It has been said that learning is the consequence of thinking. As such, experience is the true gauge by which we measure events and information. By looking at the student in terms of developmental physiological and psychological growth, we can anticipate how meaningful and successful learning situations will impact the learner. As we embark on preparing America's students to meet the informational needs and acquire skill sets for the future, it is essential to harmonize existing knowledge and theories of learning with the manner in which teachers and students will interact with technology. Possessing an understanding of how students learn will enable education reformers to determine the best use of technology to support learning.

Monitoring a child's evolution through the various stages of growth and development has been the common evaluation practice. Learning theorists, such a Piaget and Bruner, have written extensively on the progression of a child's cognitive abilities from one stage to the next. Typically, the maturation through stage development paralleled the content, quantity and quality of information and instruction provided during the traditional kindergarten through 12th grade progression. Students of all ages proceeded in a time-dependent, lock-stepped fashion through the K-12 sequence. As a result, budding learners were forced to curb their intellectual curiosity and queries in the interest of maintaining the structural hierarchy dictated by clearly-defined grade and age levels.

In the last decade, two revelations occurred that will have a lasting impact on the way we educate our children. The first was the availability of computer technology in the classroom. The second was the re-examination of our educational system so that, as a society, we can more effectively prepare students for the information age and the 21st century. While computers have been commonplace in business, industry and within military circles, it wasn't until the early 1980s that they became affordable and available for student and teacher use in the classroom. At about the same time, A Nation of Risk (1983) was published, clearly indicating a need for change in the way we equip our students with the thinking and decision-making skills that will be required for the future. With educational restructuring and the implementation of education technology, schools can be transformed so learners will become independent, self-sufficient problem-solvers in a student-centered, cooperative learning environment.

3.1 Developmental Stages

3.1.1 Early Elementary

Children entering primary school arrive with a natural desire and curiosity to draw meaning from their world. Cognitively, the young learner absorbs information through multi-sensory processing. To gather further meaning and information from concepts, the child interacts visually, auditively, tactilely and kinesthetically with the learning environment. They benefit from visual aids and demonstration, attend to verbal discussions and presentations and engage in hands-on or manipulative activities. Good and Brophy (1990)

assert that there are three kinds of learning that seem most appropriate for the child just beginning formative schooling:

- development of knowledge about familiar experiences and observable phenomena
- exploration and manipulation of concrete objects
- learning opportunities and practice of basic knowledge and skills

Young learners need repeated opportunities to experience and utilize knowledge of concepts learned in order to establish automaticity in their ability to transfer and extend skill development. Providing linkages from earlier learning to new experiences enables the child to formulate concepts and apply them to various, novel situations. The repetition of learning activities will further enhance conceptual development. Children tend to learn specifics first and build up to abstract generalizations only after they accumulate additional experiences. Thus, learning at this early stage is characterized by the necessity to build foundations through the presentation of learning tasks.

Prior to entering school, it is likely that the child has observed and experienced the operation of video cassette recorders (VCR), microwave ovens, automatic teller machines (ATM), among other technological innovations common in the home and the community. Children approach their initial formal schooling with assorted technological experiences that were not available or commonplace for present-day educators during their own school years. Thus, educational leaders and planners operate on misconceptions regarding children's benefits from and interest in further extending their experience with computers.

Education technology has demonstrated itself to be a powerful means for engaging young minds. Computers and other appropriate technological software appeal to the young learner visually through the presentation of bright colorful graphics, auditorily through the playback of sound and music, and tactually/kinesthetically through various methods of interactivity using such tools as keyboard, mouse, joystick and touch-sensitive screen.

Young children benefit from early computer use because of the computer's simple operation, consistent interface, independent or cooperative group access, ever-patient repetition of information, consistent feedback and the presentation of information in a non-threatening, non-judgmental learning setting.

The infusion of education technology into the early elementary classroom is another way to reinforce the use of traditional manipulatives and hands-on resources via a medium that is well within the learner's worldly experiences. Appropriate technology for primary schools enables the child to engage in basic skill development in mathematics, reading, writing and other content areas through a wide assortment of technology tools or instructional software. Computer-assisted instruction programs provide a fun way for children to receive additional practice in basic skills development. Primary learners are able to extend their language arts ability through interactive engagement with CD-ROM stories, capture their imagination by writing a story using a word processing program, or represent their creativity by graphically

drawing or painting images with a computer. Children who demonstrate ease-of-use and an ability to utilize various forms of technology should be provided further opportunities to extend their proficiencies with technology. Additionally, providing young learners with access to education technology shows them that computers and other mediums are an integral part of lifelong learning and not an isolated element of their formal schooling.

3.1.2 Intermediate

The intermediate student is generally still considered a very active participant in the learning process. Developing greater independent thinking skills, this learner is capable of accomplishing remarkable demonstrations of his/her knowledge. Rapid mastery of enhanced communication skills, a more defined sense-of-self and the ability to assume responsibility for learning contribute to a portrait of a highly capable emerging student.

Students at this stage are able to capitalize on their multi-dimensional, multi-sensory approach to learning gained during the primary grades. Cognitively, they are capable of engaging in inductive and deductive reasoning to address and solve complex problems or learning situations. Acquired language skills signify the ability for students to take on almost anything they perceive to be within their experiential world. They are usually able to understand principles of logic and are capable of "decentering," having the ability to look beyond one solution to multiple aspects of a problem.

Emotionally, intermediate-grade students are typically self-confident and demonstrate high self-esteem. They recognize responsibility for their own behaviors and are easily impressionable. Their expanding perceptions of the world enable them to develop a more adult-like sense of humor.

Physically, brain development has reached near full maturation. The child at this level is able to enjoy a wide variety of physical activities, manifested by greater coordination with gross motor skills and the ability to manipulate tools and small objects with ease. Interfacing with computer technology should pose no threat or problem for the intermediate student.

A technologically-enriched environment nurtures intermediate-aged learners to process information independently or cooperatively within small group settings. Students are able to work collaboratively towards a common goal by communicating with peers, teachers and parents through a variety of modes. In addition, students are able to develop collectively a class project using word processing, database, spreadsheets, desktop publishing, telecommunications, or multi-media presentations, thereby representing the outcomes of their learning. Thus, intermediate learners are able to expand the use of education technology initially introduced in the primary setting by utilizing technology in productive, creative formats.

3.1.3 Middle School

Middle school students find themselves evolving from a period of child-oriented experiences and interests to a time of dramatic physical, emotional and intellectual growth. The maturation process into early adolescence occurs

over approximately a five-year-period spanning from ages nine-to-fourteen (Berger, 1988), but the actual occurrence of the physical "growth spurt" leading to puberty varies greatly from individual to individual. The middle school student is a very social being, but also very egocentric due to the intrapersonal physical and emotional changes taking place. Thus, the effective learning environment must be structured and responsive to the unique intellectual and maturational characteristics of middle school students.

Students at this age level progress from concrete operational thinking to formal operational thought. Cognitively, middle school students *begin* to possess the ability to think analytically, predict the outcomes of research questions or experiments, integrate knowledge from one area of study with the next and communicate such analytical thought more freely with peers and teachers. Accompanying the exploratory and inquisitive nature of the middle school student is the need for self-exploration in a multitude of educational pursuits and environments.

The students' dramatic and uniquely-experienced changes frequently impact intellectual growth capabilities. Therefore, a promising approach for America's teachers would be to give students ownership and choice in the direction of their educational programs. This pedagogic strategy further supports the premise that children may learn more effectively if they have a choice in their curricular endeavors and perceive such pursuits as meaningful to their own lives. This, in turn, leads to greater opportunity for learners to maximize their learning potential.

Recent educational trends indicate a move away from the junior high school model, which has traditionally focused on content acquisition, to the middle school approach, which pays greater attention to the whole child (McWhirter, 1990). Students at this age/grade level benefit from a teacher who sets clear expectations, defines parameters of work or assignments, is consistent and, most importantly, functions more as a guide and coach than the traditional classroom teacher. Thus, the effective middle school teacher pays attention to the whole child by:

- implementing interdisciplinary teaming that incorporates, flexible scheduling for school work and assignments and team teaching/clustering
- structuring cooperative learning environments
- including the affective elements of curriculum
- moving towards a concept-centered rather than subject-centered curriculum
- providing exploratory programs of study
- emphasizing the mastery of critical thinking skills
- enhancing positive teacher-student relationships

The pedagogical tasks listed above are consistent with the student-centered approaches implemented by educators using technology. Cooperative grouping and project-based learning activities provide the appropriate learning conditions for middle school students to explore their own defined educational pursuits. The incorporation of education technology further

enables exploration in group (or individual) projects and is limited only by one's imagination (and the limitations of technology resources in the classroom). Working in a learning environment where computer technology is available further reinforces core concepts and principles through writing practice and creative expression, information access, desktop publishing activities, multi-media development and presentations and the overall improvement and mastery of computer competencies. The availability of computer technologies for middle school students will further expand their capacities and skills through an interdisciplinary approach to effective learning.

3.1.4 Secondary

According to Piaget, high school students' cognitive capabilities are functioning fully at the formal operational level of intellectual development; the student engages in abstract reasoning to deduce creative solutions to complex problems. Learning is often structured around integrative concepts that promote conceptual understanding (Good & Brophy, 1990). The instructional strategy of providing a learning atmosphere that facilitates the development of integrative concepts across different subject areas is consistent with the goals of the educational restructuring and high school reform movements taking place across the country.

The *Carnegie Foundation's Report on Secondary Education in America* proposed four essential goals for the high school learning environment:

- help all students develop the capacity to think critically and communicate effectively through the mastery of language
- help all students learn about themselves, the human heritage, and the interdependent world in which they live through a core curriculum based on sequential human experiences common to all people
- prepare all students for work and further education through a program of electives that develop individual aptitudes and interests
- help all students fulfill their social and civic obligations through a school and community service

The report also acknowledged the transformation of society from the industrial age to the information age, identifying technology as the vital link between the information revolution and the need for effective teaching and learning practices. It further advocated that a smoother transition from school to adult life could be accomplished by permitting more flexible class scheduling and by recognizing that learning opportunities for secondary students could take place both on and off the high school campus.

The secondary schools need to accommodate the rapid changes across the world by providing students with educational experiences that have real-life applications. Many of these real-life experiences already include various aspects of using technology. Thus, it is important that the secondary education learning environment supports and nurtures collaborative efforts, provides access to ideas and resources across disciplines as well as across the globe, and encourages interdisciplinary instruction across the curriculum.

Some examples of real-life technology-oriented capabilities that should be available to all America's secondary high school students include:

- accessing information from the school's media center by using an electronic card catalog
- searching information beyond the school walls through "online" or telecommunication mode
- researching information on an encyclopedia stored on a CD-ROM compact disk
- preparing for a trigonometry exam by using a graphing calculator
- drafting 3-D designs using the latest autocad, or computer-assisted design program
- writing and publishing the school newspaper by using word processing, graphics, scanning and desktop publishing applications
- studying for an exam or preparing for a standardized test by reviewing computer-assisted instruction programs in the form of tutorials, drill and practice, simulations, or problem-solving activities
- creating a prototype of a community bank in which a school utilizes sophisticated spreadsheet application, complete with interest-bearing savings accounts and possible loan distribution for those important events like proms and homecoming dances
- developing multi-media presentations that include use of a still video camera, CD-ROM or laserdisc player, and a VCR

The above list represents only a small sample of technological possibilities for schools. Examples of instructional disciplines currently incorporating technology include:

- *vocational education* -- students gain experience with up-to-date software currently used in business, such as state-of-the-art office automation technologies
- *biology and chemistry* -- a variety of probes or measurement devices interface with a computer and gather data automatically
- *music and band* -- computer systems are equipped with MIDI interfaces so students can experience meter, rhythm, pitch and volume to explore music composition possibilities
- *computer science* -- students interested in formal programming instruction and applications can create programs that may provide a foundation for advanced college coursework in mathematics, engineering, or computer science

In addition to the specific examples cited above, many computer applications are not discipline-specific. For example, innovative student creations in the form of a hypermedia or multi-media presentation can easily be applied for instructional purposes or developed for project-based learning. Subject areas such as literature, social studies, math, foreign language, physical education and health can all benefit from the computer applications readily available for student use. In order for high schools to prepare learners adequately for the necessary work and academic skills required in the information age,

America's schools at all age and grade levels need to commit to excellence by providing the technology students and teachers will need for future success.

3.1.5 Adult Learning

Consistent with the other age/grade levels discussed, adult learning has changed dramatically as a result of the preponderance of information available. The SCANS report (See Section 1.3) identified five competencies that the 21st century worker will need. The skill set identified will be required for the young adult pursuing a new vocation right out of school, those who wish to pursue further educational training in either a trade or vocational school, and those pursuing a professional degree from a four-year college or university. A common thread interwoven into all three career tracks is the need for knowledge and experience with technology.

Regardless of which career is chosen, technology will be utilized as part of daily operations. Today, technology is evident in such diverse fields as auto mechanics, dental hygiene, insurance and engineering. Our society will need to hone its technological skills to compete in the global marketplace that will characterize the 21st century.

The need for learning will not cease after adults are gainfully employed. Within private industry, government and education, technology evolves at such a rapid rate that continuous education and training will be required. Trends indicate that computer technologies improve all aspects of quality, quantity, size and affordability at an alarming rate of change. Technologies seem to double their speed, efficiency and capabilities every two years. Because the use of technology is becoming increasingly more common, educational and training needs will be constant. The sooner we recognize that the information age is upon us and accept the responsibility that all workers need to become "lifelong" learners, the more effective we will be at competing in a global marketplace.

David Thornburg (1991) described a second revolution, Renaissance II, where intellectual pursuits cut across many subject areas. He asserted that this new Renaissance will apply to all members of society, including our children. He also claims that participation will not be optional, but, instead, will be the key to our economic and social survival. "Lifelong learning was a luxury in the 16th century, but it is a survival skill today."

3.2 Multiple Intelligences

All learners process information in distinctly personal ways. Cognitive scientists have reaffirmed a strongly-held belief that no two people learn exactly the same way -- a fact that makes the teacher's job now and in the future much more challenging and complex. The best lessons almost inevitably include several presentations of the same material, but in widely varied delivery formats. Recent studies of learning have revealed a host of philosophies on how we process information. Among emerging theories, that of multiple intelligences has been widely embraced by practicing educators. Howard Gardner in his work at Harvard maintains that human beings possess seven kinds of intelligence, and that we rely on each of the intelligence types in highly personal ways.

The educational system that is able to teach effectively to all seven intelligences recognizes that each student possesses a unique style and thought process that renews a natural joy for learning. The reality that one teacher must teach to the collective mind of twenty-five-to-thirty students occupying a classroom in an individual manner defies rational thinking. However, the use of computer technologies can help the student to pursue any subject area through his/her dominant intelligence, while increasing the facility of the remaining six intelligences" (Thornburg 1991).

"From the beginning of the personal computer revolution we have been told that this technology would allow for the individualization of instruction. Now with this powerful (Gardner's Multiple Intelligence) theory to guide us, we can bring the dream into sharp focus" (Thornburg, 1991).

A brief summary of the different intelligences follows along with suggestions for applying education technology to support further their development.

- *Linguistic intelligence* -- Characterized by students who love literature, enjoy reading, writing and listening to stories and possess a good memory for specific bits of information. Education technology can enhance this intelligence through use of a word processor and other writing programs. Any instructional game or software activity that involves word puzzles or vocabulary activities will be intrinsically interesting for individuals gifted in linguistic intelligence.
- *Logical-mathematical intelligence* -- Characterized by students who think conceptually, engage in abstract reasoning to address problems, appreciate strategy games like chess and are skilled at classifying and categorizing objects and concepts. Education technology can enhance this intelligence through the conceptualization and pre-planning of a database or spreadsheet and through problem-solving and computer programming software.
- *Spatial intelligence* -- Characterized by students who think graphically to depict mental images, draw and design 3-dimensional objects, and gravitate toward visually-stimulating diagrams and materials. Education technology can enhance this intelligence through draw, paint, or graphic production software programs that require logical clue analysis and hypermedia projects.
- *Musical intelligence* -- Characterized by students who think in musical tones, play a musical instrument and learn different things in their environment auditorily. Education technology can enhance this intelligence through software programs that enable the user to add music or sound to their presentations, compose musical scores by using a MIDI interface with a computer, or interact with programs that associate letters/sounds with music.
- *Bodily-kinesthetic intelligence* -- Characterized by students who communicate with gestures and learn through hands-on, manipulative approaches to learning. Education technology can enhance this intelligence through keyboarding or word processing programs, educational programs that enable the user to move objects around on the screen and software programs utilizing an alternate input device.
- *Interpersonal intelligence* -- Characterized by students who care about others, learn effectively in cooperative groups and are involved in extra-curricular activities. Education technology can enhance this intelligence through telecommunications programs that enable the user to connect with another individual through electronic mail, programs that involve social issues or concerns and educational programs that engage the user in group decision-making activities.

- *Intrapersonal intelligence* – Characterized by students who like to be independent and act alone, are self-motivated and need their own work space to be productive. Education technology can enhance this intelligence through self-paced programs that challenge the individual to compete against the computer, or educational programs that encourage self-awareness and evaluation.

When matching education technology to multiple intelligence, it is important to select software products that offer multiple approaches and formats. Educational software should enable the student to learn critical curriculum content and skills by engaging learner strengths. Software products should enable the application of critical thinking skills and problem-solving strategies that meet the processing and instructional needs of America's learners.

4. THE IMPACT OF TECHNOLOGY ON SCHOOLS

"A bevy of technological ripples unleashed during the past few decades is now merging into a tidal wave of new technology. The knowledge age economy it will spawn will be mobilized not merely by automation but by intelligence, and will be filled not just with information but with comprehension."

- Louis J. Perelman, 1992

4.1 Learning

The impact of information technology on learning will be so enormous that Lewis J. Perelman has declared it will mean the end of school as we know it (1992). While there are many reasons to disagree with Perelman's conclusion (Bracey, Pearlman, & Thornburg, 1993), there can be little doubt about technology's potential to alter what is learned and how.

Seymour Papert has argued that a 1893 century doctor plopped down in a 1993 hospital would literally be lost, due to how information technology has revolutionized the practice of medicine (Papert, 1993). Papert calls for a similar transformative revolution in schools, noting that it hasn't happened yet.

Perhaps the greatest change in the way students learn will come from the interactive nature of information technology and students' subsequent increased control over their own learning. Earlier technologies, while often touted, kept the student in a passive position, a position that interferes with real learning. As Charles Silberman observed (1970) in the highly-advertised system, Individually Prescribed Instruction, the key word was "prescribed," not, "individually." With the maturing of educational information systems, we may expect the balance to shift towards individualization.

Technologies such as hypermedia permit each individual to peruse text and graphics according to personal needs and interests, not according to some preplanned sequence. Students, as they become managers of their own learning, will need assistance in making their informational peregrinations fruitful. Otherwise, they may end up lost in hyperspace. On the other hand, one study found that young children learning to read acquired more when they had hypermedia assistance including help with pronouncing new words, comprehending text and linking pronouns to their referents (Boon & Higgins, 1992).

To date, only a few programs begin to illustrate the potential of technology in supplying information. Some programs contain encyclopedias or entire collections. For example, a single videodisc contains the National Gallery of Art treasures. Zooming in for a close-up is not possible, but the disc includes a number of detailed figures and images of the entire painting or sculpture. We can expect more of these developments that make information management more a condition of learning than information access. In the past, information was scarce; now it is abundant.

The new technologies permit learning to occur in ways not previously possible. Today's students can observe a species of bird and hear its song at the same time. On another diskette, they can read about various styles of music -- big band, small ensemble jazz, chamber groups, symphony orchestras -- and listen to individual instruments as well as orchestras. A "musical tour" can be organized in a variety of ways, including

historically. In "Dance of the Planets," a teaching program about astronomy, students can assume a perspective from outside the solar system, speeding up or slowing down the planets as needed to observe relationships, or they can "take a walk" around the solar system while all 9,000 displayed stars maintain their proper relative positions.

While individual programs will provide powerful learning environments, the combination of programs and technologies will expand the learning setting even further. Thus, one group of eighth graders studied about the search for the Titanic by watching such films as "A Night To Remember," and "Twenty Thousand Leagues Under the Sea," watching videotape of the PBS series on the search and reading about the exploration in books (Bracey, 1992). Because these students lived in Rhode Island, they were able to visit Robert Ballard, the scientist who headed the expedition, at his office in the nearby Woods Hole Oceanographic Institute. There, they videotaped an interview for further reference. After these activities, the class divided into teams and used what they had learned to guide them through a computer simulation of the search. During this project, mathematics instruction was oriented around the reading of coordinates, while biology explored the life of the deep and physical education discussed the physical demands of such an endeavor. After completing their own search, the students developed a multi-media program to explain to the rest of the school what they had done and how. It should be noted that in addition to making use of various technologies, these students engaged in learning activities highly consonant with learning concepts that have emerged in recent years from the field of cognitive psychology.

4.2 Teaching

The impact of computers and other technologies on teachers is also likely to be quite powerful in time. Historically, computers entered schools through the advocacy of a single computer "buff," and often did not impact the rest of the building residents aside from those individuals cajoled by the buff. More recently, computer acquisition has been more likely to occur as the result of building- or district-wide efforts (Becker, 1992). As is often the case with people and innovation, teachers have responded to computers with initial caution and concern over how the introduction of technology will impact them. A fair amount of outright anxiety has been observed (Bracey, 1985).

More recently, however, studies conducted by different researchers at different times and with different methodologies have all reached similar conclusions: given computers and sufficient time, usually four-to-six years, teachers will make effective use of computers and in the process, change their teaching roles and techniques substantially. The changes are consonant with the kinds of teaching reforms being proposed.

In these studies, computers were first used by teachers to assist them in doing what they were already doing. Little innovation was noted. Over time, however, conditions began to change. Said one study:

> "As specialization of computer skills emerged, teachers recognized that there was an instructional capability in-house. As a result, they could inquire and get support to learn new software and new skills, and receive help to accomplish tasks with programs they did not know well. These collaborative activities also established new relationships among the faculties that resulted in more productive work settings. Several teachers reported collaboration on course

> development, on the development of common classroom procedures and on reducing the time necessary to accomplish common administrative tasks" (Sheingold & Hadley, 1990).

Another study found that, in time, computers changed teachers views about learning. The teachers became "more disposed to view learning as an active, creative and socially interactive process than when they entered the program. Knowledge is now held more as something children must construct and less like something that can be transferred intact (Dwyer, Ringstaff & Sandholz, 1991)." Such views are in accord with the current, constructivist theory of cognitive development held by cognitive theorists Dewey and Piaget.

Various studies on teachers using technology conclude that the computer acts as a "great equalizer." Said one, "Teachers and administrators universally reported a better sense of professional competence as a result of mastering the computer. As a minimum, they can state they 'now know as much as the kids' (Rockman, Pershing & Ware, 1992)." Once teachers become comfortable with the computers, changes in instructional technique were observed:

> "[The computer] opened a path to a new instructional strategy that would engage students in a highly collaborative and creative activity. As teachers reached this stage independently of each other, their roles began to shift noticeably, and new instructional patterns emerged. Team teaching, interdisciplinary project-based instruction and individually-patterned instruction became more and more common at all of the sites. To accommodate more ambitious class projects, teachers even altered that foundation of the traditional school day: the master schedule" (Dwyer, Ringstaff & Sandholz, 1991).

Such changes will become widespread as computers make more conspicuous appearances in the curriculum.

4.3 Management

Educational managers in America will face many new challenges in the 1990s such as school-based management and school restructuring. They will be held accountable for not only how schools are managed but, increasingly, for how decisions are made.

Educational managers are required to analyze and communicate a diverse array of information with a wide variety of audiences on matters such as current educational research and practices, student progress, policy issues and curriculum evaluation. Data on educational programs as well as students and employees must be readily collected. The information must be analyzed and retrieved in a variety of formats in order to produce sound decisions. In addition, financial information needs to be available on a regular basis so that educational managers may appropriately monitor the expenditures of limited resources.

Early on in the manager's use of technology, John Diebold (1984) tells us that it is natural for managers, at any level, to use technology to automate what they are already doing – grading, scheduling, taking attendance and typing. However, nothing really changes at this stage except, when properly implemented, the task is performed more efficiently. The real benefits accrue, Diebold suggests, when we begin to reconfigure the tasks and enhance roles because technology is available. In addition,

the use of technology opens up new possibilities in the way we organize and analyze information. However, current literature supports the assumption that technology alone cannot solve the management problems of the school superintendent. Just as we would not expect student writers who use word processors to experience dramatic improvement in their writing without concurrent attention to the development of writing skills, we should not expect improved school leadership and management through the use of technology without concurrent attention to developing leadership and management skills (Perkins, 1985).

Changes in society and education make it more important than ever that educational policy makers continually assess the school environment as a means of facilitating school improvement. Therefore, educational managers must find new ways to manage information and provide leadership for the attainment of goals and expectations within school systems. Technology can not only provide information to assist them in making the best decisions, it can also be used to simulate alternatives for comparison.

With the advent of newer information technologies, modeling systems (computerized databases and/or spreadsheets) are now available that can present a structured approach for solving managerial problems. Our understanding of management has expanded in business, government and now in education. As a result, we can employ quantitative methods as a way of improving our qualitative judgments. It is largely because of the computer that we are able to make "visible" the possible results of our decision-making processes.

The most difficult challenge educational managers presently face is to reduce the gap between the power of the technology and their abilities to understand and use that power effectively to achieve their goal of providing quality education to all students. The availability of technology in educational management provides another catalyst for rethinking the ways in which we structure, organize and manage our public schools as we attempt to meet the contemporary needs of students.

4.3.1 Policy and Regulations

All of the advances in education technology have implications for the development of appropriate policy to help govern the proper use of information. There are state and federal laws concerning access to information, copyrights, access to technology resources for persons with disabilities, use of electronic networks in the public sector for profit, appropriateness of language used in electronic mail and bulletin boards, etc. In the 21st century, these issues will become even more central as school systems sort through their implications.

Education technology systems of the future must come to grips with these policy issues and render systems that:

- protect original sources of information
- allow sufficient security to protect liabilities of people and institutions
- provide decision-making information at all levels
- lead humans to better decisions

As use of telecommunications and electronic mail become more common and accepted in this last decade of the 20th century, policy statements need to be developed and implemented that will address issues of security, confidentiality and ethics. Open and public access to information sources will help contribute to a more informed and connected society. However, the availability and security of advanced technological tools must be protected by America's school policies that help to govern use of present and future information systems in order to protect everyone's constitutional rights.

4.3.2 Security, Confidentiality, Ethics

The information age offers many challenges to the security, confidentiality and ethical use of information. As district-wide networks are implemented, there will be an increasing need to provide professional development aimed at ensuring appropriate uses of information. District staff must become familiar with:

- state and federal laws
- district policy
- concerns of tax payers supporting education

As information technologies proliferate in the coming years, we must respect the confidentiality of information about students and staff. Policies must be supported with professional development and appropriate monitoring of district networks.

The ethics of education technology are also becoming more complex. Districts with networks are purchasing district-wide licenses for software applications. Not all these licenses, however, provide the rights for home use of the software. The software industry is expected to standardize on licensing policies over the coming years. This will be important to teachers and other staff who access district-wide networks from their homes. Until then, all educators and students should sign a school or district-wide statement affirming that they will use electronic technology ethically.

4.3.3 Total Quality

Total quality management depends on relevant information to support decisions. Total quality education means a commitment to continuous improvement in all aspects of the education enterprise including administration, management of schools and management of the learning processes in the classroom. America's schools need the power of technology systems to support their efforts in total quality management. Decision makers need data about students and programs in order to manage effectively. Site-based decision-making dictates that school systems provide relevant information to support decisions at the building and classroom level.

4.3.4 Educational Accountability

There is little question that educational accountability demands will increase as education reform movements, now underway in many states across the nation, progress. While the full impact of Commonwealth reforms on accountability is yet to be determined, it is clear that education data will

need to support local decisions made to improve schools and provide sufficient rationale for continued state funding.

What information will be required of schools? How can districts use these information sources to substantiate decisions? All educators will be held accountable in the future for the educational outcomes of their students. More complex measures will be used to gauge student progress and organizational efficiency. Schools will need to monitor their progress effectively, internally, so they will be able to report local outcomes to the state governments and sustain support for continued funding of educational programs.

Schools do not currently possess the tools necessary to support and substantiate the decision-making processes. Only technology can enable the information processing required to support educational accountability.

4.4 Equity

The equitable access and distribution of technology in schools spread across many educational domains. Some of these domains include gender issues, socio-economic status, ability/capability levels (handicapped learners, gifted and "regular" education) and multicultural concerns. Equity concerns will loom large in considerations of how to deploy computers. While many states are revamping the way they fund schools, none has yet reached the point where rich and poor districts are equitably funded.

Technology has the capacity to enable poorer schools and districts to acquire the instructional resources that, for many years, only affluent schools could obtain. For example, several of the recently-released science videodiscs and CD-ROM programs contain a plethora of instructional resources from a myriad of media (slides, film clips, photographs, etc.). Five years ago the cost of these instructional materials as stand-alone products in traditional media modes would have cost approximately $30,000 and would require various types of audio visual equipment -- an investment that is well outside the range of poorer schools. Today, however, a $495 science videodisc containing these same materials and accessible through a single equipment source gives students and teachers in poorer schools access to the same high-quality instructional materials previously available only to the wealthier schools.

Care also needs be taken to ensure that computers do not inadvertently increase gaps between high- and low-achievers in America's schools. At least one study has found this to occur largely as a result of the way that computers were used. Hativa maintained that "as long as a CAI (computer-assisted instruction) system for individualized learning works in a uniform mode for all students, there will always be students who benefit from some particular type of work, while other students, with different aptitudes and styles of learning, will face problems working in that particular mode" (Hativa, 1988).

Considerations of equity are also formidable when dealing with the handicapped. For some students to be able to take advantage of a computer's power, substantial modifications in the equipment have to be made. The development and use of assistive and adaptive devices have enabled all students, regardless of physical abilities or limitations, to utilize technology to facilitate their learning.

Enormous immigrations in recent years have left schools in some states in a position of having to teach substance while also teaching English to a substantial proportion of the population (Hodgkinson, 1992). It is unclear whether students who have not yet mastered English will be able to follow the directions involved in operating programs.

Gender equity concerns are less problematic as teachers can allocate resources equitably without a great deal of difficulty. However, some attitudinal change may be required for girls to benefit more from computers. Some reports indicate that while girls learn as much as boys in a CAI setting, they see the use of computers more as a "boy thing."

Overall, considerable care must be taken to ensure that information technology does not increase the already substantial inequities in some schools, but rather decreases the equity gap.

5. LINKING EDUCATION REFORMS AND TECHNOLOGY

"As we enter deeper into a highly technological, rapidly changing, information-oriented society, the present structure of our educational system will become more and more inadequate! With our entire nation still at risk, we are forced to reevaluate and restructure the entire way schools operate, the approaches we use in teaching and the way students learn."

- Charles M. Reigeluth, 1988

During the past decade, the need for widespread education reform became the focal point of educators, politicians, and the general populace. The 1983 publication, "A Nation at Risk," helped to bring national attention to the declining effectiveness of schools in preparing our students to be contributing citizens of tomorrow (Morgan, 1992). At about the same time, microcomputers were becoming increasingly available in schools. However, educators had few ideas for effectively incorporating technology into the instructional environment, further fueling the growing national concern that schools were ineffective. Campoy (1992) pointed out that the school reform movement had taken two divergent paths towards addressing the deficiencies in the educational system:

- addressing the need for school improvement from within the existing educational system
- restructuring the entire educational system to focus on developing student-centered learning as opposed to the traditional textbook-based curriculum

The first approach, spurned by the shortcomings identified in "A Nation at Risk," sought to improve schools through stricter accountability requirements for the existing structure (Campoy, 1992). Reformers supporting this approach view technology as playing an important role in standardizing and automating instructional and administrative procedures so educators are better able to achieve set goals. "In other words, existing practices will be made 'better'" (Campoy, 1992, p. 17).

The second approach, triggered by the Carnegie Forum on Education and the Economy report, *A Nation Prepared: Teachers for the 21st Century*, calls for incorporating technology within systemic change. Those advocating restructuring view technology as being an essential catalyst to bringing about systemic change to education reform (Campoy, 1992; Morgan, 1992; Ray, 1991; Reigeluth, 1988; Reigeluth, 1992; Reigeluth and Garfinkle, 1992; and Smith, O'Day, and Fuhrman, 1992). Restructuring with technology involves a shift to learner-centered instruction, cooperative learning opportunities for students and collaborative efforts for teachers, and a de-emphasis from the traditional school/class time constraints. It also involves active engagement in problem solving and assessment based on performance outcomes instead of isolated bits of knowledge as measured in achievement tests (Bagley and Hunter, 1992; Newman, 1992).

In the last ten years, educators have attempted numerous, but fragmented approaches for incorporating technology into the education reform movement. In the *Educational Media and Technology Yearbook for 1990*, Wood and Smellie issue a warning that we are in danger of repeating old mistakes. They cite an excerpt from a 1977 speech delivered by the first US secretary of education, Terrel H. Bell, addressing the snail's pace at which educational changes take place relative to technology.

> "The education system is having a slow and difficult time adopting technological advances which could multiply the efficiency of instruction. Much of the task of storing and retrieving information and presenting it to students will be done by the computer. ...We must somehow learn to persuade

> the decision makers to shake up and change our approach to teaching and learning. The potential of technology must be used to provide the nation a more effective and productive education enterprise. American education is wobbling down an electronic avenue in an oxcart!"

Bell's quotation is remarkably appropriate today, given the isolated, quick-fix approach commonly adopted for including technology to facilitate school reform. America must stand poised to employ technology to restructure education in a cohesive and systematic manner that will successfully prepare today's students for tomorrow's challenges.

5.1 Thematic Curricula

An essential ingredient and one of the primary rationales behind the whole education reform movement is the need to move traditional classroom curricula away from content-specific facts and information, and re-focus attention on students becoming active, engaged learners. In place of rote recall of specific facts, curricula should emphasize depth of understanding, knowledge construction through analysis and synthesis of real-life problems, and the integration of content and sound pedagogy (Smith, O'Day, and Fuhrman, 1992). "The basic drivers of the systemic reform strategy would be curriculum frameworks that set out the best thinking in the field about the knowledge, processes and skills that all students should know."

Curriculum frameworks provide a basic structure within which educators can organize more specific curricular themes to be planned and taught in classrooms. Thus, curriculum frameworks provide teachers with broad parameters for developing instructional units or activities that will help guide learners toward the attainment of learning outcomes.

Kentucky is in the process of implementing a new curriculum framework that is centered around six broad learning goals that are further broken down into 75 learning outcomes. The six main learning goals in "Transformations: Kentucky's Curriculum Framework" are:

- Students are able to use basic communication and mathematics skills for purposes and situations they will encounter throughout their lives.
- Students shall develop their abilities to apply core concepts and principles from mathematics, the sciences, the arts, the humanities, social studies, and vocational studies to what they will encounter throughout their lives.
- Students shall develop their abilities to become self-sufficient individuals.
- Students shall develop their abilities to become responsible members of a family, work group, or community, including demonstrating effectiveness in community service.
- Students shall develop their abilities to think and solve problems in school situations and in a variety of situations they will encounter in life.
- Students shall develop their abilities to connect and integrate experiences and new knowledge from various fields with what they have previously learned and build on these learning experiences to acquire new information through various media.

The terminology relative to curriculum reform encompasses many variations. "Integrative education" is becoming very popular across the nation, yet some unique

interpretations exist that require further clarification. Shoemaker (1991) identified and defined the different approaches common to the genre of integrated or thematic curricula. Two of the most common approaches associated with such curricula are:

- *Interdisciplinary* -- Maintains traditional subject boundaries while aligning content and concepts from one discipline with those of another.
- *Thematic* -- Subordinates subject matter, allowing the boundaries between disciplines to blur. Topics can be narrowly or broadly focused.

Interdisciplinary and thematic approaches to integrating curriculum are differentiated by the specificity applied to a given topic (thematic unit) in contrast to the overlap that exists between two or more subject areas (interdisciplinary). The exploration of thematic units within the K-12 curriculum eliminates traditional limitations on learning, such as given time frame, classroom, and teacher.

The effective use of technology within thematic curriculum is often the thread that ties two or more content areas together. For example, an intermediate level (grades 4-6) thematic unit might focus on birds. Student activities might include reviewing various species of birds by observing and recording the activity around the bird feeder located outside the classroom window. Examples of incorporating technology might include:

- viewing a variety of bird species indigenous to their geographic region on a *CD-ROM* disc
- recording daily observations onto a *spreadsheet* where students could analyze and graph their end-of-the-week results
- utilizing a *draw* or *paint* program to illustrate their bird observations
- communicating their observation results to students residing in other areas of the state via *telecommunications*

Within one thematic unit, students study life science, mathematics, humanities/arts and language arts. In addition, students engaged in the above examples are replicating real-world, problem-solving activities with available technology. Thus, an appropriate thematic topic enables students to employ a variety of skills and to see curricular connections and overlap with content areas. In this sense, a computer tool is only as good as the curriculum in which it is used (Hill, 1993).

5.2 Learning Approaches

5.2.1 Cooperative Learning

Cooperative learning is an extensively-researched instructional method in which students work together in small groups (typically two-to-six members) to achieve a common goal. Groups are typically chosen heterogenuously with attention given to social background, skill levels, physical capabilities, gender, and learning style. Group dynamics and the ability to work toward common goals will be effective if some appropriate collaborative skills are taught to group members, such as record keeping and consensus building. "Additionally, research has demonstrated that the process of learning cooperatively actually improves the acquisition and retention of content and skills throughout the curriculum" (Dockterman, 1991, p. 85).

The need for integrating such skills into real-life are further supported by SCANS, which examined the needs of the workplace and whether young people are capable of meeting those needs (US Department of Labor, 1992). All five competencies identified by the SCANS report (see section 2.3) are consistent with outcomes sought by the educational restructuring movement in America. Specifically, the *interpersonal* skills competency matches the similar skill set expected of cooperative learning work groups.

Given the limited resources available to most schools, cooperative learning has frequently been implemented as a strategy for dealing with technological learning opportunities. Cooperative learning strategies build on student strengths, where students receive rewards and recognition based on their individual and group performance. Cooperative learning enables the student to assume greater responsibility for his/her success (Banks, 1993). The use of technology provides both the individual student and his/her cooperative to create their own knowledge base, and expand the possibilities for learning through shared, group-work activity.

5.2.2 Project-based Learning

Given the diversity that a restructured curriculum will offer students, teachers will be responsible for managing a more multi-dimensional learning environment. "The classroom of the future, with technology that allows the learner a greater degree of independence from the traditional lockstep curriculum, will require management skills and content knowledge well beyond that possessed by the typical teacher today (Berliner, 1992)." Teachers will be engaged in facilitating student learning that will expand across a broad spectrum of interests and ability. Because of the wide diversity of student interests and abilities, Berliner (1992) feels that teachers will need to be more intellectually equipped than they are today.

Students will embrace learning activities that will be of intrinsic interest to them. Therefore, the best approach is to have students work on projects with depth, complexity, duration, and relevance to the real world (Berliner, 1992). Technology will play a major role in successfully providing students with the means to explore activities of intrinsic interest. For example, students might pursue social issues such as problems that may contribute to strained race relationships, or explore the effects of acid rain in their region. Projects could be individually-oriented or group-based. Computer technologies can provide a viable means for recording part or all of the student project or activities.

The benefits of such an approach are numerous. Those involved would engage in various forms of critical thinking and problem solving. Learning activities would include collecting, analyzing, and synthesizing information; planning a course of action; or creating new instructional and/or learning materials. Some possible technological outcomes might include a multi-media or hypermedia-based project, or a report developed using all skills involved in desktop publishing, such as copy layout, scanning graphics, and creative writing.

Teachers will assist their students in the project approach by monitoring their progress and providing assistance in the acquisition of materials or technological tools that will advance their quest. The teacher's role will

require a shift from the traditional "educator" paradigm where the whole class addresses the same content area, at the same rate, for the same duration to a multi-tasking activity approach where students are engaged in interdisciplinary activities at various ability levels, spanning different time frames, with in-class and after-class work.

A basic tenet of the education reform movement encourages a style of learning that fosters greater independence, greater autonomy and individualization, a higher degree of interactivity, and greater interdisciplinary opportunities and use of intuition (Barr, 1990). The technology tools available provide students with a model for thinking systematically to address the correct steps and strategies that will enable successful problem solving.

5.2.3 Multicultural Experiences

One of the cornerstones of the education reform movement is the need to address multicultural issues in education. The "melting pot" of immigrants has changed dramatically over the last part of the century in comparison to the first half of the century.

Factual demographic examples reveal the importance and need for addressing multicultural themes in education (Bruder, 1992):

- By the year 2050, descendants of non-whites are expected to represent 40 percent of the country's population.
- Nationally, between 1978 and 1988, the Asian student population more than doubled and Hispanic students nearly doubled, while both whites/non-Hispanics and blacks declined, and the American Indian and Alaskan Native population remained virtually unchanged.
- The U.S. Department of Education's Office for Educational Research and Improvement reported that, between 1979 and 1989, the number of children aged eight-to-fifteen enrolled in US schools, who spoke a language other than English at home, increased by 41 percent. However, during the same period, overall school enrollment declined by 4 percent.

The pre-reform public school curriculum more typically reflected the world of white, middle-class students from intact nuclear families. However, the student for whom this curriculum was designed does not exist today. In our urban areas, jobs are following people to the suburbs. This migration of middle America to the suburbs is having a significant negative effect on the ability of the metropolitan area to be economically healthy (Hodgkinson, 1991). With the departure of money, jobs, homes, and human resources, America's inner-city schools, where the highest percentage of "at-risk" students are found, are rapidly decaying.

When the diversity of students entering the school is coupled with a poorly-defined process of education, a high level of organizational uncertainty results (Campoy, 1992). Thus, the need to restructure our schools in order to address the increasingly diverse student population is essential. Benefits commonly attributed to the use of technology have proven effective with at-risk youths. The self-paced, individual approach computers can provide for children may help alleviate the frustration level that disadvantaged

learners typically experience (Bruder, Buchsbaum, Hill and Orlando, 1992). With technology, students are encouraged to become problem solvers instead of asking the teacher for the answer. Technology has also been shown to be helpful in addressing the needs of ESL and LEP immigrant populations. Meaningful input, social interaction, risk taking, and purpose are key to successful second language acquisition. Lalas (1993) reports that education technology has been successfully used to help build instructional environments that provide these critical success factors into a global village. Teaching respect for cultural diversity has become critical for creating good citizens of the global village as technology continues to shrink the world. James (1993) reports on the use of telecommunications as a tool to teach respect for cultural diversity and to help immigrant students become aware of their native culture and traditions. Incorporating technology into our schools can be the first step in decreasing "at-risk" percentages and increasing the delivery of productive citizens.

Upon reviewing the relationship of multicultural issues with technology, three deficits become apparent. Bruder (1992) reports that there are limited resources or products available that specifically address multicultural education. This is a problem that is beginning to be tackled by the Bank Street Colleges' Center for Children and Technology in New York, where researchers are examining what software developers need to consider in order to achieve a multicultural balance in their products. Second, given the consistent trend in our urban demographics, school children need to have culturally diverse educators modeling appropriate uses of technology. The changing demographics of our urban schools dictate the need for minority teachers in general (Griego Jones, 1991). Further efforts are required to recruit minority preservice teachers to become effective users of technology so they, in turn, can serve as another reminder to culturally diverse communities of the need to incorporate the technology tools that will be common in the 21st century. Third, as was demonstrated with the Earth School lab in Harlem, New York, equitable access to technology will yield positive results. Inequities in school funding must be eliminated for all the nation's children to have the opportunity to receive a high-quality education (Banks, 1993).

5.2.4 Exploratory Learning

Exploratory learning is a strategy that enables the student to interact in a discovery mode by utilizing technology through the power of multi-media. Multi-media refers to the combination of video, sound, graphics, still photography and animation through computer-controlled CD-ROM drives, videodisc players, computer hard disk drives, sound speakers and video monitors. The equipment and related software lets the user select, create, edit and play back any part of the material at hand (Skolnick, Larson, Smith, 1993). Hypermedia technology allows for a web of interconnected knowledge that enables the learner to move in a non-sequential way through a conceptual information space. Thus, the computer environment fosters learning through discovery and personal experience (Jacobs, 1992).

Through the use and creation of projects or activities with multi-media, students are enabled to explore new dimensions of learning. They can interact with the explosion of information available in a variety of forms. More importantly, today's students have opportunities to interact with various

forms of multi-media because the skills of locating, organizing and using information are reinforced through their experience with technology. This translates into a more effective preparation of today's students for tomorrow's work force. Technology serves as a means to an end, never the end itself.

Student-created multi-media projects help individuals further explore the facets of their own multiple intelligences. The medium enables the learner to assume various roles involved in the development of the project. Students quickly begin to see the value of the producer, director, camera operator, editor, and writer involved in the creation and orchestration of a project. The project can be individual or group-oriented, with the end result being an appropriate example of an alternative and futuristic form of assessment.

5.3 Heterogeneous Grouping

One of the goals of the education reform movement is to provide equal learning opportunities for all American school children. "Equitable" opportunities for learning are interpreted in many ways. The most effective and immediate way for schools to provide equal opportunity is to eliminate the "tracking" system of separating students based on their academic ability. If elements of restructuring education are to move beyond the rhetoric commonplace in education reform literature, heterogeneous grouping of students in schools and classrooms needs to be developed and established. Heterogeneous grouping is defined as the grouping of children with differing ability levels. Once school policy makers and administrators support the elimination of ability grouping and encourage the practice of heterogeneous grouping, a positive learning environment reflective of the real world can be created for the children and adults who learn and teach in it (Villa, 1992).

Soloman (1993) reports that recent studies on heterogeneous grouping indicate these can provide the greatest opportunity for learning to take place. Results show that those students in the middle or average ability range tend to thrive when mixed with children representing all academic abilities. Those students commonly referred to as above-average or gifted fare about the same academically whether they are segregated with their similarly-capable peers or grouped with students representing varying ability levels. However, the more capable students also gain an improved self-concept, an increased awareness and appreciation for individual differences, and the valued ability to respect the rights and responsibilities of those different from themselves.

The students who tend to benefit most from heterogeneous grouping strategies are the weaker students. These students, frequently characterized as "at-risk," gain the most because they respond favorably to higher expectations placed upon them and to the challenging assignments to which they are exposed in contrast to the basic skills and remedial-like nature of the work they are traditionally assigned. In addition, these weaker students interact with positive role models who tend to possess stronger communication, study, writing, and interpersonal skills.

The ability for teachers to create a learning environment for all students to succeed does not come about without some difficulties. "Educators are being asked to promote all students to the highest levels of work *and* to address differences in learning styles and rates of learning. That's no small task" (Solomon, 1993). Reform-minded educators can take advantage of what they know about the benefits of cooperative learning and apply these strategies to heterogeneous groups.

Use of technology can serve as a common denominator for all students in heterogeneous groupings. Employing technology, students can apply various skills, abilities and multiple intelligences in a cooperative work effort. Besides resulting in a small group work environment that would enable more capable students to assist less able ones in a non-threatening, supportive manner, technology supplies an opportunity to maximize learning potential. Children functioning in a student-centered, small group-based learning approach will benefit greatly from teachers' abandonment of the lecture-oriented, top-down instructional method in favor of the facilitator, coach, mentor, and team leader approach that the restructured educational curriculum encourages.

5.3.1 Inclusionary Education

The inclusionary model of education refers to the incorporation of handicapped children in all instructional activities with students of the same age. In the recent past, children with handicapping conditions were typically pulled from their regular classroom environment and sent to a specialist with qualifications in specific areas of exceptional education. As a result of the inclusion movement, special education will commonly function as a support to regular education programs and personnel within the regular classroom setting. A collaborative model of regular and special education teachers working together in a team teaching approach will be prevalent (Saks, 1993).

Technology will play a key role in this education reform effort to ensure equitable education for all. Full inclusion implies that regardless of any handicapping condition that may exist, students will receive their education with their same-age, non-handicapped peers. This is possible through recent advances in the development and implementation of assistive and adaptive devices to the field of education technology. The definition of Assistive Technology from Public Law 100-407 states, "The term assistive technology device means any item, piece of equipment, or product system, whether acquired commercially, off-the-shelf, modified or customized, that is used to increase, maintain, or improve functional capabilities of individuals with disabilities."

Applications of assistive technology in the classroom open a new world of possibilities in the education of the child with a disability. Augmentative communication and adapted computers enable a child to take full advantage of the education environment in ways never before imagined. Increasing awareness of these new tools and their potential by educators, reinforced by informed parents and federal legislation, is paving the way for the goal of self-sufficiency for every child (KATS Network, 1992). The inclusionary grouping strategy further advances the education reform premise that all children should have access to equitable education if they are to meet their individual needs (Shaw, 1990).

5.4 Ungraded Primary Programs

There are many distinct subtleties when it comes to reviewing the elements associated with the education reform movement in America. One age/grade level that is associated with a unique terminology is the primary programs and associated grouping strategies. Katz (1992) identified and defined the terms nongraded and ungraded as typically referring to the process of grouping children in classes without grade-level

designations and with more than a one-year age span. Primary programs, typically characterized by the traditional grades of kindergarten through grade three are being classified as "ungraded" in an effort to reflect the continuous progress a child might demonstrate according to individual rates of learning and development. As a result, children would not be restricted to fixed-time or age-related achievement expectations or promotions.

Teachers are encouraged to create a learning environment where students perform in a quality-oriented system. All those involved in the education of a child, including his/her peers, acknowledge each student as an important individual who has social, emotional, and intellectual needs. Expectations are high that children can achieve success through their respective learning efforts and activities. Records are maintained and feedback is provided to the child and parents through a portfolio comprised of an assortment of work effort, observations, self assessment, and achievement. In this learning atmosphere, children begin to challenge themselves to set high personal standards. Within this type of learning environment, the child becomes self-motivated and inherently pleased with his/her accomplishments (Calkins, 1992).

The most positive advantage to incorporating technology into the ungraded primary classroom is that at a very early age, children begin to see and recognize the computer as a regular tool for learning, and not as an isolated educational intervention. Another advantage is that the instructional software industry has learned from it mistakes in the last ten years and has begun to produce a good selection of educational materials addressing children's multiple intelligences, stimulating them auditively, visually, tactilely and kinesthetically. Further, as America's schools embrace and enact education reform, young children will continue to expand their view of the world as technology assists in unlocking each child's creativity and desire to learn.

5.5 Site-based Management

Site-based management (also referred to as school-based management) places the authority and responsibility for decisions about budget, curriculum, personnel, or school policies in the hands of individual school staffs, instead of a central office or a school district. It is a new, reform-minded way of thinking about how people in a school work together to make important decisions relative to the future direction of the school. As a result, teachers, parents, and community members, in addition to the school principal, are empowered to make important decisions that lead to effective school reform.

Site-based management (SBM) teams represent a school's ability to be the "check and balance" system of the education reform movement. A primary function is to develop and implement a comprehensive plan to improve student achievement, provide training for staff members, and evaluate the program relative to its overall effectiveness. Each SBM team shares a common goal of uniting the whole school community to create a climate that helps children.

Overall, the role of technology is ill-defined in relation to its impact on SBM teams or the role that they can play in integrating technology into their schools. Technology can assist administratively with recording, managing and communicating efforts and results of SBM teams. However, SBM teams can impact the immediate and future success of technology at their respective schools by encouraging and sanctioning appropriate technology-oriented professional development activities. SBM members are significant stakeholders in determining the direction of professional development activities. Teachers at all instructional levels need more exposure to effective

strategies using technology in the classroom. Through the professional development subcommittee of the SBM team, teachers can request further staff development training opportunities in technology in order to achieve greater degrees of technological comfort and skill.

5.6 Performance Assessment

In order to prepare appropriately the youths of today for the workforce of tomorrow, major changes have to take place within the Commonwealth's educational system. Restructuring the curriculum to reflect more accurately society's evolution into the information age and beyond is a principle challenge, as well as preparing students to work cooperatively with others. Curricula, teacher methodology, and the assessment of the student's progress in pursuing learning goals all must undergo significant changes.

In the days of preparing pupils for the Industrial Age, curriculum revisions took place regularly, typically following the five-to-seven year cycle of textbook adoption. Under the umbrella of staff development or in the course of teachers returning to graduate school for additional training, educators were exposed to contemporary or the most "effective" instructional strategies supported by research. The area of education that has undergone minimal changes, while other areas intermittently receive infusion of new ideas or concepts, is the manner in which a student's progress or acquisition of knowledge is measured. The traditional paper-and-pencil test method of assessment with either teacher-made or standardized instruments have not addressed the pupil's total performance or capabilities.

A growing number of educators are beginning to recognize that as school reforms dictate a need for change in curriculum and instruction, the manner in which they evaluate teaching and learning must also change (Bruder, 1993). Reform-minded educators have begun to assess how a student performs a task that requires in-depth understanding of a skill, and to evaluate how effectively the student communicates that understanding to others. The method of performance-based assessment demonstrates that a person's capacity to learn is more accurately reflective of his/her ability to perform or produce than his/her ability to answer on cue. "The student is to perform with knowledge instead of merely recalling or recognizing other people's knowledge" (Bruder, 1993).

The role of technology in performance assessment is evolving, but is not clearly defined at this point. Technology can be used to minimize teachers' labor-intensive tasks, such as generating assessment items with a computer in order to create a test instrument that can easily be adapted or edited to target various student populations or ability levels. The problem with this use of technology is that it perpetuates the old paradigm of requiring students to have finite pieces of information to answer questions correctly. With the performance assessment approach, the correct response to a test item is likely to contain multiple responses. What really matters is the knowledge and information in the selected method or approach by which the final response was determined.

Teachers can utilize technology today by implementing an "electronic portfolio" of students' work using recording and storage products. A student will be able to progress through the years at a school, adding work samples and products at each grade level. Upon completion of his/her formal K-12 education, a student will carry a CD-ROM disk filled with years of reports, art, class work, biographical information, health records, significant accomplishments and more (Solomon, 1991). The electronic portfolio then represents a meaningful guide and historical record of the student's growth and needs.

Bruder (1993) briefly reviewed various forms of technology incorporated within performance assessment activities:

- Teachers using a bar code reader on a recording sheet walk around the classroom to record their observations of a student's work, noting whether a task is "mastered" or "developing" for a given skill.
- Teachers customize the bar codes to reflect the learning objectives in the lesson or unit of instruction.
- Students call their parents on a telephone installed in the classroom or on a cellular phone to inform them of an accomplishment in a "real-time" progress report.
- Teachers and students videotape student work in process to record the concepts being developed, and at the conclusion of the event, the videotape serves as a basis for evaluating progress toward the attainment of the initial concept.
- Students create a multi-media presentation and record the achievement on disk.
- National Computer Systems (NCS) is developing the technology so teachers can capture student work in whatever form it is produced -- handwritten, computer-generated, video, or audio.

The benefits of technology for education are not limited to only instructional or learning approaches. The above list is but a cursory view of different ways technology can be used to monitor and record a student's work that is representative, not only of a culminating event of instruction or learning, but also as a means for capturing the "process" of learning. This will enable America's students to become more reflective learners because of the self-evaluation and monitoring that effective uses of technology affords.

5.6.1 Authentic Assessment

Authentic assessment includes performance tests, observations, open-ended questions, exhibition, interviews, and portfolios that represent the student's work at various stages of development. Glazer (1993) notes that the term "authentic" is used because the assessment procedures replicate classroom activities. Child-centered teachers begin to provide guidance for children based on where they function. Thus, standards for performance do not come from outside experts, but rather from the teacher and child -- the best equipped experts to determine achievement.

> "The aim of authentic assessment is to engage students in challenges that better represent what they are likely to face as professionals and as responsible citizens. For an assessment to be authentic, the context, purpose, audience and constraints of the test should connect in some way to real world situations and problems" (Wiggins, 1992).

Some other assessment strategies include, but are not limited to:

- anecdotal records
- checklists to monitor a work effort or project completed by both teacher and student

- learner profile observations that are recorded according to specified qualitative criteria. For example, in "group work," the student:
  - divides a task among other group members
  - agrees on a plan for structuring a task
  - takes time to ensure that all members understand the task
  - remembers to record group progress or results

The activities associated with learning need to be broadened in order to accommodate a restructured curriculum that will prepare learners more effectively for the demands of the information age. It is no longer appropriate, nor accurate, to measure learning via traditional methods of evaluating and recording student performance. Real-life learning opportunities should be measured by authentic assessment methods that are made available through technology and are more readily applicable to real-life situations.

5.6.2 Portfolio Assessment

A portfolio is a showcase or collection of student work over time. The portfolio of work should focus more on student processes and less on finished products. They become an important source of information regarding achievements or, conversely, content or learning style areas in need of improvement.

The effective classroom teacher is likely to have already maintained portfolios as exemplified by samples of student work across various subject areas. Samples of portfolio assessment contents might include:

- reports from a group project
- excerpts from a student's daily journal
- notes from an interview or conference
- teacher-completed checklists
- self-evaluation reports

The use of technology will facilitate the accumulation and storage of the electronically-collected materials representative of the student's work. The computer, with its ability to record sound and store writing and pictures, is a natural addition to a portfolio assessment archive.

5.7 School Choice/Charter Schools

School choice/charter schools is a relatively new education reform that is quite distinct from the other reform initiatives discussed previously. In an effort to model the successful competitive spirit demonstrated in the business world and to improve public education through school choice, several states have responded by approving the formation of charter schools. Although charter schools are characterized as being public schools delivering a public education using public dollars, they differ from traditional public schools in that they are formed by individuals or small groups functioning as private non-profit organizations. They are organized around the concept of a charter or contract between the founding group and its sponsor – typically a designated governing body (Amsler and Mulholland, 1992). Some brief distinctions between charter schools and regular public schools are:

- *purpose* – provide a clear alternative to what is traditionally offered
- *organizer* - organized by individuals or groups, typically, but not limited to school personnel
- *sponsor* – present charter plan to appropriate governing boards of education at the state and local level
- *contract* – hold charter school accountable to meet minimum standards of the state
- *autonomy* -- make all instructional and administrative decisions for themselves
- *accountability* – charter can be revoked if school fails to meet student outcome objectives
- *governance* – by-laws/governed by board of directors
- *funding* – funded directly from the state on the standard per-pupil basis
- *admissions* – cannot exclude students based on specific qualities

The primary reason for establishing a charter school organization is to break away from the bureaucracy typically associated with large school districts. Additionally, charter schools enable families from lower socio-economic status to decide on the appropriate schools for their children. This privilege has usually been limited to the middle- to upper-class students through the choice of private or parochial education. Since charter schools have become an accepted means of providing education in some areas of the country, charter schools attempt to free themselves from the slow process of change typically associated with larger school systems. Forging a direction on their own, charter schools feel they can offer a more reform-minded education to the students and families in their school community.

Whether students and teachers in charter schools will make greater use of technology than those in the public schools is difficult to tell at this time. A definitive debate on the overall effectiveness of implementing technology in a charter school does not exist. The potential benefits, such as less red tape and more unified school and community goals for implementing technology, could easily be interpreted as a liability because of the lack of expertise and resources available to support such an endeavor. The school choice/charter school movement is less than three-years-old. Results on the use of technology in these schools will be made available in a short while. Thus it is difficult to project the effective implementation of technology and computers until charter schools finish their period of orientation.

6. CREATING EXPANDED LEARNING ENVIRONMENTS

"In an effort to provide relevant 21st century skills promoting life-long learning, educators have successfully identified and incorporated a variety of alternative learning environments into the current curriculum. Many of these environments are rich in technology resources. The alternative learning environments of 1993 will become the foundation for America's schools of the 'virtual learning environment' of the year 2000."

- Cyndi Dunlap, 1993

The term "classroom" no longer adequately defines where learning occurs. Learning is situated in cognitive, social and physical activities which can occur in diverse learning environments when enabled by technology. Many diverse learning environments can exist within one physical location depending on the needs of the learner. Learning environments are more accurately defined by technology resources and access to information they provide, regardless of physical or geographical location.

Dr. Frank Withrow, Director of Learning Technologies for the Council of Chief State School Officers, observes that, "High-performance communication and computing technologies are capable of providing text, audio, video and interactive learning experiences to learners at home, in school, within the community and at the work place. Such learning stations can access digital libraries of learning resources. Such technologies will radically alter our concepts of education."

To date, in scattered initiatives across the nation, expanded learning environments have been a successful means to address and achieve the following goals:

- provide relevancy to content and contextual materials
- provide access/equity to all learners within the education environment
- address the 21st century skills of accessing, analyzing and communicating information
- develop higher-order and problem-solving skills
- provide exposure to real-world applications, problems and solutions
- develop sense of self and community
- promote skills that develop life-long learners

The challenge for leaders responsible for implementing education reform is to demonstrate the courage to break with the paradigm for traditional learning environments. If the educational restructuring initiatives advocated across the country are to move beyond the "change" rhetoric that cyclically appears in the professional literature, then education must take a futuristic view of learning, including the environment in which the change can be nurtured. Students at all age levels will be able to acquire knowledge and experience beyond the classroom walls. Expanded learning environments must be conceived to enable practical instructional and learning opportunities to occur.

6.1 Expanded Learning Environments of the '90s

A review of the expanded learning environments in place today provides a glimpse of the many options and possibilities which, if actively pursued, will bring about by the year 2000, the "virtual learning environment" -- an environment that enables students

to learn what they want, when they want and where they want. These expanded learning environments fall into six broad categories:

- global classroom (telecommunications and distance learning)
- library/media information centers
- community outreach/service (libraries, museums, municipalities)
- public education/higher education partnerships
- education/business partnerships
- home, school, community connections (nursing homes, adult communities, hospitals, day care)

Electronic communications with the installation of local-area networks (LAN) and wide-area networks (WAN) will enable access to resources that have always been considered remote from the classroom learning environment. Information from a variety of community sources will soon be readily available to students and teachers in the classroom and to families from their homes. Information that has typically been considered too difficult to acquire will now be available, literally, at one's fingertips.

6.1.1 Global Classroom

Telecommunication and advanced technologies make it possible for students and teachers to collaborate and share resources. Simple telecommunication -- the transmission of data over telephone lines using a modem connected to a microcomputer or a sophisticated two-way voice, video and data transmission via satellite in a distance learning classroom -- present both teachers and students access to a world of information. Across the nation, for example, students in rural, urban and suburban areas are using Kidsnet to share information regarding the impact of acid rain on water quality.

Science teachers and students participating in the Technical Education Research Center's (TERC) Global Exchange Network access edited satellite pictures from a national database that is updated hourly.

In Billings, Montana, students in grades K-8 are beginning to understand the significance of events happening in the outside world. Each of 71 classrooms is equipped with a digital telephone and voice mail system. During the 1992 presidential campaign, to complete a writing assignment regarding the positions of the three major candidates, students called outside sources including Bill Clinton. Using the speaker phone, the entire class was able to share the experience of speaking with the president.

In some of the most rural communities in New Mexico, high school students are taking advanced courses from a college 50 miles away through a two-way interactive video system. Through this innovative application of technology, students can participate in a regional classroom and have access to educational resources not locally available.

A distance learning solution provided by TI-IN Network of Texas provides educational services to children of migrant workers in more than 1,000 schools, serving nearly 6,300 students in 42 states. The service provides for

instructional continuity, making it possible for students to complete course work and accumulate graduation credits.

Using software called CSILE (Computer Supported Intentional Learning Environment) installed on the school's computer network, a student at the Huron Street Public School in Toronto contributes his/her own ideas to a knowledge database, and reads and comments on the ideas of others. Students create and include drawings and even link different ideas and drawings into a larger hypertext document. Others in the class travel through these ideas, thinking about the material in more depth -- placing ideas and misconceptions out in the open. This approach even changes classroom dynamics. Conversations are not dominated by the most vocal students; shy students and girls get equal time.

Benefits of the global classroom as an expanded learning environment for students in America include:

- engages students in global issues where individuals can make a difference
- promotes acknowledgment, acceptance and appreciation of cultural diversity
- broadens personal experiential base of knowledge
- provides equity through shared access to global resources
- allows students not able to attend school due to illness, extended hospitalization, or other extenuating circumstances "classroom participation" and access to a multitude of resources

The availability of telecommunication possibilities has already begun to shrink our world. During the Gulf War crisis, our awareness of the impact and horrors of war were instantly brought to our consciousness through the presence of CNN and satellite cable television. Visual images of bombing targets and of human suffering were available in "real-time." Children in Seattle, Washington, gained far greater insight to the human trauma involved. Students and teachers were able to exchange electronic mail with an Israeli family whose members were sealed in an isolated bomb shelter in an effort to avoid the fallout from SCUD missiles targeted on their community and homeland. For the American children linked to this family in Israel via Internet, the understanding, compassion and fear they experienced from communicating was far more real than what could have been planned for in a teacher's lesson. The access and timing of this type of information can enhance learning and enrich people's lives.

6.1.2 Library/Media Information Center

The American Association of School Librarians and the Association for Educational Communications and Technology assert that " the mission of the library media program is to ensure that students and staff are effective users of ideas and information." In many schools, the traditional library has assumed the title of Information Resource Center. Librarians have been quick to jump on the technology bandwagon to automate circulation, cataloging and inventory control, thus becoming users of technology for greater efficiency and accuracy. It is no wonder this group of individuals has played an active role

in bringing educational technologies such as laserdiscs and CD-ROMs into the schools. School library media professionals have recently seen their role redefined -- information specialist, teacher and instructional specialist for print text and electronic information and technologies. An integrated approach to teaching information literacy skills is one that combines classroom objectives, activities and assessments; and involves the classroom teacher, the library media specialist and the student in relevant applications.

Among the benefits of the library/media information center as an expanded learning environment for the Nation's students are:

- students learn to identify appropriate information from a wealth of sources
- students determine appropriateness/usefulness of information for a given task
- students examine and apply information to make and test hypotheses
- located centrally, the library/media information center provides more or less equal access to all students and teachers
- provides unlimited access to a variety of information resources required to embrace education reform approaches such as cooperative learning, interdisciplinary and thematic study and the teaching of higher-order thinking skills

Library media specialists should be supported as they expand their roles in student learning. In many ways, these professionals function as gatekeepers of knowledge and information. The educational process will benefit greatly from a more collaborative approach between teachers and library media professionals. Media specialists will benefit from keeping up with the education reform changes taking place in instruction, while teachers and students will need to learn more about the burgeoning quantity and quality of material available within the Information Resource Center (traditional library).

6.1.3 Community Resources/Services

Students and teachers are infiltrating their communities in search of data for collection, manipulation and experimentation. Armed with portable computers, powerful database software and probes for gathering data, students are experiencing "real-science" and engaging in "real research." The "classroom without walls" takes on new meaning when students use modern technology to gather information about the immediate world in which they live. Museums are designing technology-enhanced exhibits to attract, educate and entertain visitors. At the secondary level, students are offering their services to communities in return for projects that present them with real-world problems to solve.

In the spring of 1993, 115 students and 10 teachers were trout fishing in a nearby creek armed with 21 computers, an integrated software package and a charting tool. The goal -- to establish a baseline of information on trout migration. The result -- a multi-media presentation for the town council and the fish and wildlife advisory board. The entire school curriculum for the

semester was fish-oriented, with students studying everything from trout biology to environmental law.

The Computer Museum in Boston is launching The Computer Clubhouse, an innovative learning space where underserved youth can use powerful computer tools to create projects reflecting their own interests. The space includes elements of an artist's studio, newsroom, science lab and a music studio for the creation of electronic music, multi-media projects, robots, "virtual worlds" and scientific simulations.

Visitors to The Children's Museum of Indianapolis, Indiana, are introduced to physics principles through interactive video kiosks at an award-winning exhibit entitled "Indianapolis 500." The material is also available to educators in two formats - as a videotape of five one-minute segments introducing physics principles, accompanied by a teacher's guide; and as an interactive videodisc incorporating the five one-minute lessons, a bar-coded teacher's guide and accompanying software.

Elementary students in Abita Springs, Louisiana, visit local historical sites, interview representatives from ethnic communities and invite guest speakers into the school as they research and produce a multi-media database documenting the town's cultural diversity. The interactive presentations are often used in settings ranging from K-12 classrooms to libraries and chambers of commerce frequented by adults.

The benefits of using the community as an expanded learning environment for America's students include:

- opportunities for students to demonstrate competence
- student exposure to primary sources
- development of a social connection to people and places
- avenues to explore a variety of careers and initiation into occupational networks
- enhanced self-esteem and sense of empowerment by "giving something back"

The availability of portable technology, such as laptop computers, enables both teacher and student to access learning opportunities that have evolved from an isolated environment into the reality of a "portable" classroom. Community resources can offer a great amount of information that has been underutilized. Children can see real-life applications of important math or science concepts, observe a variety of careers and vocations and develop a sense of ownership and pride in their community.

6.1.4 Public Education/Higher Education Alliances

Alliances and/or collaborations between the public school sector and higher education have formed across the nation to improve individual schools and reform the larger educational system. An example worth exploring is the 1991 alliance between the Pueblo, Colorado School District and the University of Southern Colorado. The motivation behind the agreement is the desire to strengthen the quality of academic preparation and educational

opportunities available to students in the school district. Students are challenged to master a curriculum that rewards analytic and critical thinking and sustained intellectual effort, not just the rote memorization of facts.

The National Faculty of Humanities, Arts and Sciences, originally an affiliate of Phi Delta Kappa, is a 24-year-old organization that connects K-12 teachers with college professors on projects suggested by local educators. This organization is a school/college collaborative roadshow with university scholars heeding the call of educators in need.

The Five College/Public School Partnership consists of Amherst, Hampshire, Mount Holyoke and Smith Colleges and the University of Massachusetts at Amherst working with rural, urban and suburban schools in four counties in western Massachusetts.

Not only the public school sector stands to gain from these partnerships; schools can provide a number of benefits to college partners as well by:

- providing better-prepared students who require less remediation during their freshmen year and stay in school longer
- allowing colleges access to grants from the US Department of Education that focus on school and college collaboration
- sharing professional development activities where professors learn a great deal about pedagogy from teachers
- publicizing positive shared experiences resulting from the alliance

Benefits of public education/higher education partnerships providing expanded learning environments include:

- creation of an atmosphere conducive to change and a sense of participant empowerment wherein all partners are required to contribute
- ability of college partners to bring legitimacy to alternative solutions for identified problems
- increased access to internal and external sources for funding to supplement time for teachers to learn new technologies and to purchase software and equipment
- shared use of facilities and significant sharing of faculties
- jointly-designed curriculum development with a K-16 perspective
- extensive use of external readers or examiners across the high school/college boundaries
- student opportunities to integrate work and learning through apprenticeship-style programs linked to community colleges
- facilitate movement across institutional lines for students

The linkage and communication between higher education and K-12 public schools has historically not been strong or constant. Successful, but isolated collaborative efforts between colleges/universities and K-12 schools do exist

and are taking place across the country; however, much more can be gained by increasing such partnerships.

From a national perspective, the education reform movement in K-12 schools has been underway for almost ten years. However, a vital source of communication to share successes and setbacks is needed between higher education and public schools to enable more effective training at both the pre-service and in-service level of teacher preparation and professional development. Traditional means of teaching need to be challenged at all levels of instruction. If teachers are going to be effective at utilizing and assisting students with technology applications, then instructors/professors in higher education must follow suit. Otherwise, the presentation of outdated methods and strategies will result in the preservation of an instructional model appropriate for an industrial age society.

6.1.5 Education/Business Partnerships

As the number of education/business partnerships increases, educators should heed past lessons. The education community should acknowledge that industry has much more to offer than just money or equipment. Business people can help educators in:

- developing personnel training
- establishing liaisons with state and federal legislators
- negotiating the politics of obtaining support for schools
- managing multimillion-dollar budgets

Adolescents use their growing capacity for critical thinking to question whether what they are taught in school will make a difference in their lives. The challenge of engaging students with learning has lead educators to rediscover apprenticeship. "Cognitive apprenticeship" describes a mode of classroom teaching characterized by mutual engagement in "authentic" tasks as contrasted with didactic exercises. Cognitive apprenticeship brings realistic problems into the classroom, where they become the focus of students' hard work. "Youth apprenticeship", in contrast, attempts to create engaging learning opportunities in workplaces, not only in classrooms. In Broome County, New York, employers are designing learning programs for youth apprentices who are juniors in high school. One key feature of the design is planned rotation through a range of departments and work assignments in order to ensure breadth of experience. Apprenticeships often include a mentor who can give advice about education and career plans.

In some European countries, we even find schools located in the workplace and operated by employers who not only offer apprenticeship, but also the classroom instruction and general education that goes along with the work experience.

Employers of the 21st century will seek employees with a sound mastery of academic knowledge and skills combined with the ability to work cooperatively, solve problems and continue learning throughout their lives. In response to this need, cooperative education is a solution that involves

students in carefully planned and supervised work experiences that are well-integrated into their schooling.

As a result of education/business partnerships providing expanded learning environments, students experience:

- the relevancy between basic academic skills and real-world applications
- manipulation of authentic data
- sense of purpose and community membership
- career options and education opportunities
- links to occupational networks

The powerful concept of partnership itself cannot be overstated. Success hinges on long-term commitment and cooperation. Partners are committed to a project because they share a common vision and goal, and are actively involved in achieving its aims and contributing to its success, thereby creating a sense of ownership. A truly collaborative venture, where individuals are empowered and institutional resources committed, appears to gain a life of its own and sustains involvement over the long process of implementation.

6.1.6 Home/School/Community Connection

Hampered by employment schedules, family activities and limited access to classroom teachers beyond the end of the school day, few parents experience regular communication with their child's classroom teacher. An increase in parental involvement, participation and communication with school personnel has been realized through the integration of technology.

The Buddysystem Project is a joint effort between the state of Indiana and corporate sponsors to integrate technology into the curriculum and link the home into the learning process. The project has provided students access to computers with multi-media software, courseware and word processing programs in school and at home. Parent workshops on the various software programs are held at the school as a prerequisite for taking the computer home. The approaches used to involve parents and families center around parent training and interactive homework.

Software applications that open lines of communication between parents and teachers are also available. A computer and telephone supply touch-tone phone access to daily assignment information, project due dates, athletic events, PTO/PTA activities and cafeteria menus. Voice mail options allow parents to report student absences as well as send and receive messages from individual teachers. Improved communications foster a greater commitment and sense of ownership in members of the education community.

Schools that use technology to broadcast instruction via their cable television systems also open doors to other community populations seeking to enrich their lives through continuing education. These individuals may be found in nursing homes, retirement centers, daycare facilities, senior citizen centers and in their homes where they are confined for a variety of reasons.

Interactive television promises to be the next technological breakthrough on the horizon to enter the home environment. Over a dozen mass communications-based interactive services are slated to appear during the next few years, including interactive entertainment, education, banking, voting, shopping and video on demand. Each service offers a slightly different level of interactivity using a variety of technological solutions. Public educators require access to equally powerful technology to create effective, engaging learning environments.

Expanded learning environments can improve home, school, community connections in America through:

- improved relationships and cooperation with parents selecting home schooling
- improved communication among students, parents, teachers and administrators
- broad-based support from the community-at-large
- increased technology literacy within the community
- greater participation in and commitment to school improvement and reform efforts

6.2 Redesigning the Architecture of Schools to Accommodate Expanded Learning Environments for the 21st Century

In the September 1993 issue of *Educational Leadership*, Anne Taylor suggests the concept of "three-dimensional textbooks" for school facilities. "Reflecting new visions of learning, educators and architects are creating 'three-dimensional textbooks' that use the learning environment as a teaching tool."

To accommodate new teaching styles such as interdisciplinary learning and team teaching, schools require updated classrooms. They need computer labs, outdoor ecological landscapes, spaces for art, teaching museums and furniture systems and designs to meet the needs of students with disabilities. New environments are also needed to foster lifelong learning, preschool through old age.

In schools that are three-dimensional textbooks, students move through educational spaces, using them for different reasons and retrieving their own information. Among the 18 features Taylor identifies for schools implementing the three-dimensional textbook model, the following are highlighted.

- Hallways are vertical and horizontal learning surfaces offer graphics, displays for student artwork, or informational mini-museum exhibits.
- Lighting and windows illustrate lessons about the science of light, changing angles of the sun, seasons and solstices.

- Teachers have space for dialog and planning, with a professional library close to the work area.
- Systems are simple, designed to be operated and maintained as much as possible.
- Schools have museums of history, art and science, with students as curators.

The Lincoln Unified School District in Stockton, California, conceptualized its new school with the assistance of architects, students, community members and school staff. They have envisioned a community learning center that will supplement existing offerings in the district and community. Community and physical resources will become part of the environmental three-dimensional text book.

In Trout Lake, Washington, after the community defeated bond issues for a new school building for six years, an intergenerational community center was approved. The library will be a state-of-the-art system available for community use and connected by the latest technology to data banks around the state, the nation and the world. Student involvement in the design process gave the students a sense of ownership in a real-life project to solve a community problem.

Raymond Farley, superintendent of Hunterdon Central Regional High School District in Flemington, New Jersey successfully garnered support for four prototype classrooms of the future that support self-directed learning and incorporate state-of-the-art technology. The first two prototypes, biology/chemistry and applied technology, repurposed space in the old 1,900-square-foot wood shop and 1,850-square-foot metal shop. With low student enrollment in these shop areas, which translated to an occupancy rate of 25% each day, the selection represents a shift from the factory era to the information age.

The examples could continue for pages as pockets of innovation have been documented across the nation. District leaders willing to experiment and take calculated risks based on research, community input and a strong, broad-based commitment to educational improvement have met with many successes worthy of investigation and evaluation. All educators must follow their lead.

6.3 The Role of Technology in the Transformation to a "Virtual Learning Environment"

The "virtual learning environment" concept will link a number of activities students engage in at school, at home and within the community, all assisted by and managed through powerful technology networks. America's schools must use technology to provide the basis for life-long learning skills and strategies.

This theme is eloquently restated by Dr. Frank Withrow, Director of Learning Technologies for the Council of Chief State School Officers; "In a modern, information-rich society, citizens must have ethical standards, employable skills and be able to make judgments in a participatory democracy. The educated person of the 21st century will be a life-long learner who knows how to access information and turn it into meaningful knowledge... Technology is the universal tool for life-long learning." The Computer Systems Policy Project (CSPP) suggests, "An information infrastructure for lifelong learning will offer unprecedented potential for improving lives by making knowledge readily available and usable by all Americans."

Just as we expect running water and electricity in the schools of 1993, by the year 2000 each classroom will have access to an "information utility." This single utility system integrates voice, video and data in a bi-directional fashion; information flows in and out from several different information sources -- instruction, administration and video. The utility allows classroom access to software servers throughout the building, communication links with other classrooms and bi-directional access to all of the audio/visual resources such as cable television, satellite communications and videodisc players. It is also possible to attach a VCR camera to the video outlet for broadcast of a guest speaker and student presentations to other classrooms and to other school buildings in the community. The information utility links all of the educational facilities including the library, the home and other related institutions such as museums, colleges and cultural centers. Fully connected using telephone lines, cable TV, science, or optical fibers, the school's information network extends to other state, national and world-wide communications systems.

Recently, the US Department of Education awarded the Florida Tech Educational Partnership a project to link Florida schools to the Internet and NREN through the Florida Institute of Technology. This project offers a $300,000 grant to provide instruction and high-tech tools to open communication and resources to the community, including parents and business.

A new national infrastructure for education has been proposed as part of the building of a national network of information superhighways. To advance innovation and reform and equalize access of information resources, teachers and students in all areas of the nation must contribute to the reform process. The pace of change in scientific research, global economic change and population demographics demand a new educational infrastructure. While states and communities are ultimately responsible for education, establishment of an infrastructure is a federal concern.

7. INSTRUCTIONAL TECHNOLOGY APPLICATIONS IN THE CLASSROOM

"You've got to remember, it took 20 years for the overhead projector to make its way from the bowling alley to the classroom. I'm optimistic. I'm beginning to see computers in bowling alleys!"

- Arthur Luehrmann, 1990

As the domain of education environment moves beyond its infancy and evolves into increasingly more sophisticated levels, the array of software tools and interventions simultaneously expands. Where once, not so long ago, computers in schools were dedicated solely to teaching programming skills, now a plethora of applications exist and continue to make their way into mainstream instructional practice. The basis for using technology in America's schools should be to promote various types of learning including inquiry-based, interactive, student-directed, lifelong, meaningful/real-world and objective-based.

The use of a wide array of technological tools and applications in the classroom enables educators to create a learning environment that provides the means by which students:

- become responsible
- focus on identified learner outcomes
- engage in cooperative work efforts
- apply learning to real life situations and experiences
- create their own knowledge structures through critical-thinking, problem-solving and important decision making
- demonstrate progress and mastery of educational goals

7.1 Instructional Technology Foundation Skills

7.1.1 Problem Solving

Because of the unique qualities inherent in educational technologies, learners can be effectively presented with opportunities to solve situational problems requiring the integration of higher-order thinking skills such as:

- defining the problem
- expressing problems clearly and succinctly
- distinguishing between fact and opinion
- using logical reasoning (deductive/inductive)
- using creative thinking (originality, fluency, flexibility)
- making decisions
- eliminating unnecessary choices
- determining desired outcomes
- searching for viable solutions
- evaluating outcomes

- revising and repeating the process as needed

Characteristics of software contributing to the development of problem-solving skills may include:

- interactivity
- open-ended branching
- simulated learning situations
- responsiveness
- user-managed options
- high degree of motivation and engagement
- clear explanation of the problem
- numerous correct solutions
- immediate and positive feedback
- options to retry and redevelop solutions

The key ingredient to remember with respect to problem-solving and the use of instructional technologies is that the user should comprise the core of the matrix. Whether the proposed problem is a real-life community situation in which data will be collected, analyzed, stored and interpreted, or whether the software itself contains a problematic context, the learner should always be afforded an opportunity to expand upon the growing base of thinking skills in attempting to seek solutions.

7.1.2 Critical Thinking

Since one of the primary objectives of education reform should be to teach students to think, then perhaps the most urgent demand put upon the school is to enhance the quality of thinking. At the center of this premise lie the following hypotheses:

- All students are capable of higher-level thinking.
- Thinking skills can indeed be taught.
- Thinking skills can also be learned.
- Thinking skills are prerequisite to the learning process.

Having established these presumptions, we might then delineate exactly which of the following thinking skills we wish to foster:

- analyzing
- questioning
- identifying central issues
- comparing/contrasting differences and similarities
- extracting relevant information
- discriminating relevant from irrelevant data
- inferring

- elaborating
- generalizing
- prioritizing
- patterning
- checking consistency
- identifying cause/effect
- recognizing assumptions
- identifying clichés, bias, propaganda and slating
- selecting reasonable alternatives
- testing hypotheses and conclusions
- predicting outcomes
- defending intellectual arguments
- appreciating the views of others

Combining more traditional strategies and interventions, educational technologies can provide rich opportunities for the development of critical thinking skills. However, the following questions must be addressed and answered in order to ensure their positive impact in the curriculum:

- Have goals been established for computer use to promote intelligent thinking?
- Are there organized methods to support the use of technology in the curriculum?
- Has the process of thinking been defined?
- Has the implementation of education environment been evaluated?
- Are teachers trained in the use of technology?
- How is software evaluated and integrated into the curriculum?
- Is technology the most effective means of promoting thinking skills in a given situation?
- Has the community been apprised of instructional and technology goals?
- Is there a commitment to secure adequate resources to support the use of technology in the thinking curricula?

7.2 Primary/Intermediate/Middle

The young student is eager and receptive to technology. Having grown up in a highly technological world where toy stores market countless engaging and motivational electronic games, this learner is generally familiar and comfortable with high-technology interfaces.

7.2.1 Reading

The highly interactive and user-managed characteristics of technology lend themselves well to the fortification and expansion of individual reading skills. Utilizing text, graphics and sound in an engaging format, reading software (i.e. laserdisc "books", integrated learning systems and stand-alone reading games) can be easily adapted to progress at the speed and level of difficulty best targeted to each individual learner. New and improving technologies, such as speech recognition, synthesized/digitized reading of text, animation and CD-ROM will positively impact the learner's motivation and ability to expand upon existing reading capabilities. For example, the following reading skills can be presented, practiced and tracked in America's schools using customized technologies:

- letter and word recognition
- vocabulary building
- decoding
- comprehension
- ascertaining the main idea
- identifying main characters
- determining themes
- retention of facts and ideas
- sequencing of events

7.2.2 Language Development

An important factor in determining successful communication between the learner and the world is the ability to develop and practice language skills. Using technology, the student practices receptive processing of information (reading and listening) and expressive processing of information (writing, speaking and drawing/painting/music composition).

Specific technology interventions that assist in this objective are:

- software games and programs promoting the reading of content and instructions
- video and cable presentations
- telecommunications
- distance learning
- hypermedia presentations
- speech synthesis software which reads text as directed by the learner
- laserdiscs and CD-ROM software that present the learner with a variety of text, graphics, animation and sound sequences for instructional support

- word processing programs
- graphics and music and other creativity software
- multi-media presentations that effectively combine a variety of resources for the purpose of sharing knowledge and ideas

7.2.3 Science Exploration

The young learner exploring the field of science has a multitude of opportunities afforded by the education environment:

- Using micro-based probes and sensors, the student can collect and compile a variety of types of data, (i.e. heat, temperature, color composition).
- Spreadsheet and graphing software assist in organizing and visually presenting information (i.e. plant growth, water analysis).
- Simulation software can place before the learner a variety of situations that are unattainable in the real world (i.e. space travel).
- Basic physics software can replicate experiments which would require inordinate amounts of equipment and involve safety hazards.
- Database compilation can be used to track and report results of classroom experiments.
- Laserdiscs and CD-ROM can bring to the learner examples of rare scientific phenomenon (i.e. tornadoes, earthquakes).
- Telecomputing programs make possible the gathering and sharing of data with other students around the world (i.e. Internet, National Geographic KidsNet).
- Hypermedia presentations can demonstrate the hierarchical branching organization in the natural sciences (i.e. mapping the Animal Kingdom with navigational buttons).

Such interventions dovetail with the scientific process by encouraging the practice of observation, experimentation, positing theories and hypotheses, testing theories and hypotheses and drawing conclusions.

7.2.4 Math Concepts

The innate abilities of the education environment to individualize the learning situation make possible the presentation of math concepts in a highly customized format. Young learners can explore the following using a variety of software and hardware interventions:

- *classification* -- recognizing attributes, patterns and groupings
- *class inclusion* -- part-whole relationships
- *seriation* -- sequencing and ordering objects
- *number conservation* -- addition and subtraction of facts
- *quantitative conservation* -- distribution of materials
- *length conservation* -- distance and time lines

- *weight conservation* -- density, mass, gravity
- *volume conservation* -- understanding of interior and exterior space
- *probability* -- predicting odds, likelihood of events
- *correlations* -- relationships
- *formal schemes* -- variations, qualitative analyses, analogies
- *formal logic* -- if/then syllogisms

Software applications which provide support for graphing, statistics, data analysis and making subsequent inferences are particularly helpful in the development of math concepts. Word problems and complex mathematical situations can be presented and offered for both independent and collaborative decision-making.

7.2.5 Global Awareness and Studies

As the world continues to shrink and its inhabitants assume an ever-greater global consciousness, the young learner will be increasingly exposed to seemingly remote situations with personal ramifications. For that reason, we are all "citizens of the world." One distinctive goal of education must be to prepare students for participation in the global arena. Therefore, it becomes the responsibility of all learners to maintain an awareness of world events and to seek understanding and resolution to problematic developments.

Areas contributing to increased recognition and comprehension of global studies include:

- a sense of historical markers and timelines
- geographic knowledge
- sensitivity to the existence of diverse cultures
- environmental responsibility
- cause and effect with respect to sociological issues

Instructional technologies can effectively address many of these topics:

- Simulation software can encourage decision-making and debate surrounding difficult problems.
- Timeline software can visually track the events of history.
- Spreadsheets and database programs can assist in collecting and analyzing data to be interpreted for better understanding of social situations.
- Telecommunications capabilities assist in reaching out and touching even the most remote of our global neighbors for promoting greater insight into their cultures.
- Collaborative and cooperative software games provide practice in delegating and assuming responsibility in a variety of sociopolitical situations.

- Demographics trends can be studied using graphing and charting software.
- Recent developments such as the Persian Gulf War can be studied and scrutinized thanks to up-to-the-moment laserdisc and CD-ROM technologies.
- Polls and surveys can be conducted and results shared instantly using computer programs.
- Community issues can be explored and reported through local bulletin board services.
- Distance learning brings experts and policy-makers into the classroom to discuss electronically issues of global concern with students.
- Numerous environmental software applications encourage conservation and/or ways to recycle in order to preserve our fragile ecosystems.
- Many programs present situational social situations in which the learner is asked to make open-ended choices based upon responsibility and anticipated consequences.

7.3 Secondary

Students at this level are preparing for entry into the real world or higher education and they are actively defining their career paths. It is clear that America's students must be prepared to assume new roles and responsibilities in direct reaction to the rapidly changing demands of society. We are asking that these learners:

- be flexible, adaptable, and informed
- have interpersonal and communication skills
- be able to work independently or in groups
- continue to be lifelong learners
- contribute in a meaningful way to the greater community
- be able to solve problems
- think critically and ethically

In very real and distinct ways, technology can assist learners in accomplishing these objectives.

7.3.1 Math

Although curricular fragmentation will give way to more thematic project-based, problem-based work, math will continue to be visibly woven as a requisite skill throughout the secondary years. Technology can be readily-used to support math-related life skills such as electronic checkbook balancing and computing simple compound interest. It can also be employed to enhance a student's communication skills, for example, interpreting data into visual statistics output and creating graphs and charts to represent numerical data. As a result of the new NCTM math standards and requirements for

critical thinking skills, the following uses of technology must be more widely employed:

- gathering and analyzing data (database, spreadsheet)
- inductive reasoning via guided inquiry
- using simulations (market and business applications)
- using technology tools to locate resources of information
- developing inferential skills by reading visual numerical data
- learning specific new math skills (tutorial)
- extending existing skills (drill and practice)
- engaging in logic and sequencing games

7.3.2 Science

The expanding focus on our world and beyond has given new meaning to the study of science. By investigating the environment and its inhabitants, the learner now assumes a highly personalized interest in this content area. We must now look at the umbrella of science as consisting of multiple integrated modules (life science, physical science, earth science, scientific reasoning and technology) that should be taught concurrently.

This approach is a requirement of the recently-released NSTA scope and sequence. Science, like math, is focused largely on real-world problems and situations. As such, the learner is drawn into the challenge of finding solutions. Possible technology applications centering on the field of science include, but are not limited to:

- Videodisc/CD-ROM collections for use as a highly visual aid motivating students based upon exploration of real world experiences and interactive simulations/models.
- Microcomputer-based laboratories that include sensors and probes for conducting scientific experiments and collecting, organizing, comparing and sharing data.
- Telecommunications applications are often used in scientific discovery to share scientific data via modem, gather results that are often posted to national bulletin boards as well as conduct significant research and compare results.
- Decision-making groupware allows large group participation in current environmental issues while facilitating open-ended exploration of significant problems.

7.3.3 English

The ability to understand and express ideas in written and spoken form determines effectiveness in all other areas; mastery of English is critical to the success of the learner. Technology assists in the acquisition of these crucial skills in the following areas:

- reading
  - books on tape

- books on CD-ROM
- disk-based books

- writing
  - word processor and printer
  - expedites the editing and revision processes
  - can obtain multiple printouts for distribution
  - can use LCD panel for peer/group critiquing and editing
  - spellcheck capabilities
  - built-in thesaurus
  - modem extends audience beyond school
  - examples of student products: stories, poems, reports, letters
- listening
  - taking turns in group editing situations
  - accepting and offering constructive criticism
  - listening to video, audio tape
  - restating skills
- speaking
  - use of microphone
  - results are often posted to national bulletin boards
  - can conduct significant research and compare results

7.3.4 Social Studies

Capable of comprehending the human issues of history and culture, the secondary learner seeks understanding by investigating underlying factors. At this point the concept of a "global village" takes on new meaning since this student will soon be in a position to affect the course of events via the vote. Given the idealism and maturity of the secondary student, this signals a perfect time to engage in stimulating and serious debates wherein the learner simultaneously practices self-assertion and the rules of social interaction. Technology can be used in the following ways:

- Simulations software applications provide for issue-based decision-making situations through cooperative and collaborative learning. It also allows students an opportunity to explore a variety of social and society quandaries and real-world business simulations while expanding their understanding of the concept of citizenship.
- Mapping, charting and graphing skills can be enhanced through software which transfers data into visual representation.

7.3.5 Foreign Language

Although the study of foreign language is finding greater acceptance at the elementary level, it is predominantly the secondary learner who attempts to master a second language. Technology, used independently or in large groups, can assist via the following formats:

- video, audio tapes, and CD-ROM
- computer software
- telecommunications (specifically the Internet)
- word processing programs that script and symbolize appropriately

7.3.6 Business

In an ideal situation, secondary learners who wished to explore the realm of business could do so in an automated office simulation within the school or through a school/business partnership apprentice program.

In order to understand protocol and procedures, students should be immersed in the day-to-day activities of a business. Technological tools which would assist in this endeavor might include computers (networked), printers, scanners, telephones (with voice mail) and modems, remote access communications (pagers, cellular phones), copy machines, and fax machines. Real world software applications such as word processing, databases, spreadsheets, calendars, accounting packages, client management, project trackers, inventory control, and electronic mail are also essential.

7.3.7 Art

Electronically-produced art forms continue to improve with the emergence of newer, more powerful co-processors and better printing capabilities. The student of art now has a wide choice of hardware and software that assist in the creation of:

- graphic design
- animation
- cartooning
- three-dimensional imaging
- tweaking and color separation

7.3.8 Music

Personal expression through music has extended to the world of technology. Using a computer equipped with MIDI (Musical Instrument Digital Interface) capabilities, the learner can now produce electronic compositions, transpositions, and scores. Additionally, the masters of music can be heard on audio CDs and magnetic media. They can be edited, evaluated, and studied with respect to such concepts as rhythm, meter, pitch, volume, and artistic interpretation. Many CD-ROMs exist today which highlight or archive the music of a particular musician or era. Finally, music can be added to multi-media productions in order to add feeling, or improve the overall quality of the presentation.

7.3.9 Physical Education

Secondary learners are at a critical time in their lives with respect to developing a self-disciplined attitude about health and fitness. This is a time when activity levels naturally taper off and when cultural pressures are often luring them to try smoking, alcohol, etc. It is perhaps the most opportune time for a student to establish a strong and solid understanding of his/her body, since growing has virtually stopped and the period of rapid changes has ceased.

Technology offers a variety of biofeedback and stress management strategies for this learner. A quick trip to any fitness center will reveal numerous examples of how electronics are incorporated into equipment for the purpose of individualizing exercise regimens. Individual fitness profiles are readily available for use in most computer environments.

Also many computer-based and CD-ROM titles in existence cover the topics of diet/nutrition, health, AIDS awareness/prevention, drug/alcohol abuse and sex education.

7.4 Vocational/Technical

The world of vocational education and "Tech Prep" is becoming increasingly more technology-based at a faster rate than any other spectrum of the instructional rainbow. In readying students for transition directly into the work world, the school recognizes its obligation to provide a highly-specialized skill base that is both soundly marketable and resilient. In order to accomplish this objective, the school vocational/technical program might offer:

- word and data processing
- computerized diagnostic systems (for auto repair)
- CAD design and drafting
- electronics training
- robotics
- landscaping architectural software
- health-related skills (using medical technologies)
- communications technologies
- chemical technologies
- manufacturing technologies
- independent and cooperative work situations

Vocational/technical programs in America should consider investigating the concept of establishing technology-rich "academies" and exploring occupationally-focused schools (i.e. Magnet Schools Grant). It would also be helpful to research internships with industry and experiment with the concept of mentor/apprenticeships. Two further recommendations for vocational/technical programs are creating occupational clusters within a school and establishing mastery standards for all students.

Because so many present and future jobs include and involve occupational technology, it is essential that these programs provide up-to-date facilities that accurately reflect the work world in order to prepare the graduate adequately for the 21st century.

8. CURRICULUM AND TECHNOLOGY

"One's mind, once stretched by a new idea, never regains its original dimensions."
- Oliver Wendell Holmes

Curriculum and technology will play an unquestionably crucial role in the futures of individual children and our world. Experts from many disciplines advise that technology should and can play an important role in curriculum planning, development, delivery, assessment, and administration.

Further, many experts agree that if America is to compete successfully in our global society, a nationally-sanctioned set of minimum curriculum standards is needed. In fact, most of the countries with which we compete already have standards. Currently, the New Standards Project is working with 19 partner states and a half dozen public school districts to create national curriculum and assessment standards. One of the co-directors of the project, Lauren Resnick reports, "we have a view of *outcome* standards [of] stating the competence that you expect of kids and not trying to specify how to get there."

In addition, technology education as a separate discipline is being updated around the world. According to Sylvia Charp, The New National Curriculum of Technology in Japan is government mandated and includes 35 hours of information technology in the lower secondary school. The objective is "to make students understand the utilization and function of computers through the operation of a computer, and to develop the fundamental ability to apply information properly." A major United Kingdom government initiative is seeking to deliver technology education for eleven-to-eighteen-year-old students by setting up a network of Technology Colleges that "meet the needs for life and work in the 21st century." Charp goes on to say, "Overall, technology education is providing students with the capabilities to survive in a very technical and rapidly changing world in addition to emerging as a primary discipline."

The rapid growth rate characteristic of emerging technologies found in today's classroom far exceeded the ideas envisioned in the minds of innovative educators over a decade ago when microcomputers first became available in the classroom. Early curricular development for microcomputers was devoted to treating computer technology as a separate discipline or subject area. Course content addressed the history of computers, learning the technical terminology of bits, bytes and the importance of knowing the relationship of binary notation to programming. Fortunately, innovative trends have evolved to where the education environment is seen as a means for students at all grade levels to pursue their quests for knowledge using an interdisciplinary approach to learning.

8.1 Curriculum Integration

In order to discuss effectively the importance of integrating education technology into the curriculum, it is essential that the traditional focus of curriculum be reframed to accommodate the reform and restructured outlook for schools. Great ideas and viable suggestions can be generated to demonstrate the integration of computers in the classroom, but unless education alters the structure of curriculum from a product-oriented, finite knowledge-base to one that is process-oriented, skill-based outcomes, education environment will merely repeat continued bad habits leading to continued poor or inferior results when we assess the effectiveness of our schools.

Current trends on education reform echo the need to alter the traditional view of curriculum to an integrated approach to learning. Educational leaders and planners acknowledge that students do not assimilate new information in clearly-defined blocks of time. Butzin (1992) asserts that even though technology is seen as the centerpiece for change in the education reform effort, the effective use and integration of technology has yet to be realized. The usual inhibitors to integrating technology effectively -- lack of classroom equipment, lack of training for teachers, poor planning and inefficient distribution of available technology resources into existing curriculum structures -- account for the slow progress towards the goal of integrating computer technology into curriculum.

Effective curriculum integration is not an impossible dream. For it to happen, educational leaders consisting of teachers, administrators, parents, and community representatives must formulate a shared vision of what comprises the integration of computers with curriculum for their respective school or district. A model developed by Sarah Butzin (1992) in Florida, entitled Project CHILD, identified several key components that need to be considered and developed for computer integration to take place. Key components incorporated into the Project CHILD model that have contributed to the successful integration of computers into the curriculum include creating a classroom environment with multidimensional instructional materials, such as books, computers, manipulative and other available technologies; structuring continuous progress of students by having teachers and students work together for up to three years; enhancing the teacher's role by developing collaborative work teams with other professional colleagues according to content area; empowering children to take increased responsibility for their own learning; managing student time and activities by incorporating an effective classroom management system; assessing students based on authentic assessment strategies; involving parents via consistent communication and the child's journal noting progress and miles.

Project CHILD is one successful model that helps to create a restructured learning environment that embraces technology. Student activities align with the constructivist approach to learning whereby, "teachers help students construct their own meaning and demonstrate their knowledge through performance-based assessment, such as portfolios and projects" (Butzin, 1992, p. 331). In the integrated classroom, curriculum provides a solid understanding of knowledge in the core curricular areas and the ability to apply that knowledge to real-life problems and situations (Reigeluth and Garfinkle, 1992).

The supporters of education reform know that the infusion of technology alone into curriculum will not produce great results. Teachers need to reevaluate and revitalize curriculum. Zorfass (1991) reports from her research that technology use was most successful when teachers brought technology into curriculum contexts where students were actively engaged in learning, where they were pursuing authentic tasks in which they were invested, and where teachers facilitated the learning process by guiding and coaching their students, not directing them. Within the context of a strong curriculum, technology use has the potential of enhancing active teaching and learning.

8.2 Curriculum Development/Instructional Management

The application of technology in the areas of curriculum development and instructional management can have a profound impact on America's schools. Just as business and industry expend their technology dollars to support the core of their enterprises, so, too, should schools investigate applying technology to their most critical aspects, the

development of curriculum and the management of students through the instructional process.

Technology that can assist educators in developing curriculum and managing instruction can be found in software systems that align curriculum, instructional resources, assessment and student information. Such systems allow for the orderly and integrated flow of large quantities of information which impacts teaching, learning, and educational management, and decision making at all levels. The manner of implementation of these systems is critical if they are to serve as an effective tool to support teacher and student creativity.

With this type of technology tool, educators are able to articulate and catalogue learning goals and student outcomes/performance-based objectives as they relate to the selected curriculum. Some of these applications provide assistance in the actual creation of outcomes by providing verb lists that are connected to the hierarchical levels of educational taxonomies (Bloom's etc.). In this manner, teachers, department heads, and curriculum specialists can ensure that higher-order thinking skills such as analysis, synthesis, and evaluation are incorporated into performance outcomes.

Once outcomes are created, these software applications allow for the detailing of instructional resources as they support the teaching processes/strategies that will lead to student acquisition of each outcome. Books, software, videodiscs, manipulatives, etc., can be correlated to specified outcomes with a comprehensive description as to the use of such materials. Teachers can also document, record, and electronically share with other teachers classroom lessons that have been successful in achieving desired student performances. This correlation of outcomes to instructional resources shifts the emphasis away from a curriculum dictated by the textbook table of contents. The textbook now becomes only one of many resources available to assist teachers in reaching the educational goals established for their students.

Student assessment can also be correlated to performance outcomes. Curriculum development/instructional management software allows for the banking of test items (multiple choice, true/false, essay etc.) and cataloguing of other evaluation methodologies (holistic scoring, teacher observable assessment, portfolio/authentic assessment) to specified outcomes. Test generation is simple as is test correction when optical scanning is utilized; test reports are varied and detailed. When a school district's student information database is integrated into the curriculum development/instructional management software system, student performance against designated outcomes can be recorded and maintained for each student for the duration of his/her enrollment in the district. Such information becomes vital to ensure continued student growth and progress from year-to-year.

When student performance outcomes, instructional resources, assessment, and student information are aligned, integrated information is generated which impacts not only the performances of teachers and students, but educational administrators as well. District leaders can easily access information that enables them to compare student performance by school, gender, specified groupings, etc. and possibly reallocate resources accordingly. It also allows them to examine critically the manner in which limited instructional dollars are being expended since instructional resources are now correlated with performance outcomes. By aligning curriculum, instruction and assessment, curriculum development/instructional management software provides the integrated data necessary to inform decision making and improve the educational process in America's schools.

8.3 Technology Competencies

In the basic curricula such as math, English, science, etc., schools determine the competencies of the students. As we move into the 21st century, schools also need to include an area of the curricula that addresses technology and identify the specific competencies that will be mastered by students upon graduation whether they are generic competencies, process-related skills or subject-specific applications. Teachers must become competent in technology as well. Although they have competencies in their subject areas, they need to expand them as the curriculum encompasses process skills and becomes integrated with technology competencies.

There are ten basic areas to consider in terms of student technology competencies:

- technology awareness
- technology identification and operation
- application of appropriate technology
- cognitive skill development
- acquisition of information (research)
- presentation/production skills
- interpersonal skills and personal growth
- ethical use
- occupational technology
- adaptive/assistive

Different requirements exist for each area depending on the level of the student, whether he/she is at the primary, intermediate, middle or high school level. For example, the primary student is expected to accept technology as part of the learning environment; the intermediate student should be able to identify technological interventions in the learning environment; the middle school student should be able to identify technological interventions in the learning and home environment; and the high school student is expected to identify and understand the usefulness of technological interventions in the learning environment, home, community and occupational environment. In the early grades and for inexperienced technology users at all levels, it is important to teach students how to use the keyboard and the tools available in technology. As students become more comfortable with technology, teachers can incorporate it in many teaching and learning activities. While most competencies are best taught by integrating them with typical curriculum areas, some others may be effectively taught on their own. However, all competencies should be identified and addressed.

Teachers require many of the same technology competencies as students but they also need additional, higher level technology skills. The curriculum cannot be successful if the students are the only ones who accept and understand the new technology. Some

additional competencies include:

- technology evaluation/assessment
- instructional integration and management
- administrative management
- professional growth

Integrating technology into the curriculum involves identifying curriculum themes that enable teachers to integrate uniquely content objectives, process skills, and selected technology competencies into a lesson plan. Technology is a tool for developing creative thinking, problem solving, and higher-order thinking skills. It provides new, exciting, interactive ways of teaching and learning and can be used to tie concepts together across the curriculum.

9. ADMINISTRATIVE TECHNOLOGY APPLICATIONS

"...data are part of an organization's intellectual resource -- the facts and knowledge which allow it to operate effectively and efficiently, and to decide wisely."

- Gerald Bernbom, 1991

For education reforms to become successful in America, wise decisions will be necessary at all levels of the education hierarchy, from classrooms to state agencies. All educators must provide leadership through their own roles in the process of managing the implementation of education improvements. Information should drive all our educational decisions. Today's schools have the information to support management decisions, but this information is not easily accessible, nor is it available in forms that help enable the decision-making process. Effective administrative technology applications are necessary tools for managing the increasing flood of information about students, programs, resources, and finances.

To serve education well in the 21st century, administrative technology components can no longer be maintained as isolated "islands of information." Instead, individual administrative technology applications must become fully integrated with one another and with information processing tools, communication utilities and reporting mechanisms. States such as New York and Kentucky have already begun to build integrated systems of administrative technology applications that can operate on a seamless network and provide useful decision-support information for classrooms, school management, district administration, the community, and state agencies.

9.1 Classroom Management Technology Applications

Teachers need access to information for decision making about students, instructional activities, classroom management, curriculum, instructional resources, budgets, and other elements of the overall schooling process. Teachers require administrative applications to help facilitate all of the record keeping they must perform on a daily basis. Communication with peers and other professionals who serve students in the classroom is another pressing concern. Teachers also need administrative tools that can help them create effective instructional materials and analyze the information that is available to them.

Twenty-first century classrooms in America will have even greater demand for a wide range of administrative technology applications. Education reform programs and the increasing need for educational accountability will add more burdens to the classroom concerning information management. Models for many of the classroom administrative technology applications needed to support future education improvements exist today. However, for several reasons, they are not widely implemented, nor are they being used with a high degree of effectiveness. The problem is that many of the current classroom administrative technology applications are:

- difficult to use
- stand-alone products
- not transportable across different computer platforms
- not integrated with companion products that need to share information
- not integrated with information processing tools

Industry trends are improving the prospects for enhanced utility of classroom administrative technology applications. Open systems architecture provides considerable promise for tying together the separate "islands of information." Also, more powerful relational database tools are emerging to enable:

- integration of data from separate applications
- automatic updating of multiple database files via a single entry
- combination of data across multiple applications
- ability to link learning activities with instructional objectives, performance assessment, instructional resources, and instructional management options

Another important industry trend is the development of administrative technology applications featuring a graphical user interface. Such new applications provide users with icons for selecting various program functions rather than requiring cryptic commands.

By the year 2000, teachers will require a wide array of standard administrative technology applications and information processing tools to address classroom management roles adequately. These will need to be integrated tools and applications that enhance productivity and provide the means for making appropriate decisions about classroom management. They will include:

- curriculum databases that relate instructional activities with curriculum objectives, resources, and student outcomes
- communication tools to transfer information to administrators, other teachers, guidance staff, and other professionals
- communication systems to reach parents
- productivity tools including word processing, spreadsheet, database, calendar management, desktop publishing, and presentation graphics
- scheduling, attendance, discipline, and grade reporting
- electronic mail, FAX, bulletin boards, and other utilities to support sharing of instructional ideas and procedures
- information retrieval from a variety of sources that can support instructional activities

9.2 School Administrative Technology Applications

What decisions will America's school leaders have to make in 21st century schools? How can information be managed more effectively to support these decisions? How can administrative technology applications empower the professional staff of a school to address school reforms and the need for accountability effectively?

School-level administrative functions will require most of the same technology tools needed at the classroom level as well as more administrative tools for aggregating information across classrooms, communication utilities for communicating and reporting information to the central office, and tools for accessing information across the district and beyond.

Schools will need more access to the traditional administrative technology applications than will classrooms. These applications will include purchasing and

budget, inventory, transportation, food services, energy management, scheduling, grade reporting, attendance accounting and reporting, and human resources.

In addition, school management functions of the future will have an increased dependence on communications systems within the building and beyond, including electronic mail and FAX, news and bulletin boards, network software library, and library databases.

Since school offices are responsible for much of the necessary dissemination of information to parents and the community, school offices in the 21st century will require a complete arsenal of office services tools such as word processing, spreadsheet, database, desktop publishing, presentation graphics, calendar management and general statistical tools. The same trends supporting administrative technology applications for the classroom will promote more effective technology tools at the school level. Advances in the deployment of relational databases, for example, will encourage the development of school-level administrative technology applications that can be integrated with one another and with information processing tools. In addition, further development of the graphical user interface will make a wide variety of applications for all school professional and support staff.

9.3 District Administrative Technology Applications

With the implementation of sweeping education reforms on the horizon, America's school districts must have sophisticated administrative tools to maintain and transmit the kind of accountability information necessary to secure state funding for their programs. District offices will need most of the management applications available to classrooms and schools and a standardized suite of administrative technology applications and analysis tools available for district-wide record-keeping and statewide reporting functions.

Several of the following applications will prove to be essential to district offices in the 21st century:

- purchasing and budgeting
- inventory and warehouse control
- payroll
- accounts receivable and payable
- personnel
- fixed assets
- transportation
- food services
- facilities management
- energy management
- teacher certification
- average daily attendance calculations
- electronic mail
- bulletin boards

- statewide reporting

District offices need to communicate with each school, the community, and state agencies. Central office staff must take the responsibility to provide leadership on matters of education improvement and must, therefore, have access to a wide array of databases and bulletin boards dealing with cutting-edge education issues. Access to such information should be as painless as possible to encourage full utilization of information resources for school improvement. Future school district networks must have the capability to reach beyond district boundaries to the larger world of education so that staff can take advantage of information about the successes and failures of others with similar aspirations.

The work of school district executives is virtually bound to information about the details of the schooling process and its organization (Craig, 1987). Yet, most districts now do not have the tools to access, process, manipulate, and analyze these information sources in support of effective decision-making processes. Effective systems that support school improvement and accountability are necessary for enhanced efficiency at the school district level. Superintendents and other district staff must consider the costs of not automating information functions versus the costs of implementing integrated district administrative systems (Drucker, 1985).

9.4 Administrative Technology Applications for the Community

Education in America must reach beyond traditional bounds to include communication with the community and integration of community resources. Classroom teachers have always had the need to communicate with the parents of the students they teach. This need will become more paramount in the future with new education reform programs, student assessment paradigms, and outcome-based performance measures. To retain the support of local communities, school districts must provide community access to the single largest community investment -- the public schools. School resources, especially technology resources, have to be made available to the overall community in order to maximize the potential of local investment in these resources.

Also required will be effective systems for communicating to parents and the overall public regarding the activities and decisions of the school system. Many school systems around the nation are piloting innovative voice mail systems that allow parents to check the assignments given by teachers to their children, leave messages for and retrieve messages from individual teachers, and select information about school/district activities and schedules for various school-related events.

It is likely that these electronic mail systems will become commonplace in the near future; future systems could include additional features to keep the community informed, such as access to school library holdings, public information messages affecting school district businesses, and forums for the discussion of pending policy issues.

Future administrative technology systems need to extend to the home and community to support both educational activities and community understanding of key issues affecting education in local schools.

9.5 State Administrative Technology Applications

Ultimately, individual states will need to demonstrate leadership in the efficient and effective use of information to substantiate decision-making processes. To maintain legislative support for education reforms over time, they must be able to demonstrate the positive impact of such programs. They must also maintain a detailed accounting of educational statistics and financial data.

These needs give rise to the implementation of a sophisticated educational network utility that must be easy-to-use and provide the necessary information sources to support education decision making at the state level. Data that is now collected on paper forms must be gathered in electronic formats available as standard reports generated by district-level administrative technology applications and automatically transferred to statewide databases.

In the 21st century, individual states will have traditional responsibilities for aggregating data, across districts, concerning the financial management of those districts. In addition, states will need to aggregate student performance data to substantiate the need for current programs and future reforms.

10. TECHNOLOGICAL ADVANCES

"In the next decade or so, microchips will contain a billion or more transistors, expanding a millionfold the cost effectiveness of computer hardware. The terminals on our desks and televisions in our living rooms will give way to image-processing computers, 'telecomputers' that will not only receive but also store, manipulate, create, and transmit digital video programming. Linking these computers will be a worldwide web of fiber-optic cables reaching homes and offices."

- George Gilder, 1991

One need only recall the computer hardware and software in schools and offices ten years ago to grasp the scope of technological change. In 1983, the IBM PC had just burst on the scene with a 16-bit processor, 64K of memory, and a 5 1/4" floppy drive that stored 320K bytes on a floppy and ran at 4.8 Mhz. The Apple IIE had an 8-bit processor with 64K of memory, ran at 2.0 Mhz, and stored 140K bytes on a 5 1/4" floppy (Sancin Jr., 1984). Both computers used monochrome displays.

The typical school computer purchased in 1993 is a multi-media computer with VGA color display, a speed of 33 Mhz, four-to-eight megabytes of RAM, a super-drive storing 1.4 megabytes on a floppy, a 40-to-80 megabyte hard drive, and a 550-megabyte CD-ROM drive. While the IBM PC and Apple IIE of 1983 cost schools $1,500 to $3,000, today's multi-media computers, such as the recently released Macintosh LC520, or a 386 or 486 IBM-compatible or clone with a CD-ROM drive running Windows, cost schools $1,500 to $2,000 or approximately $750 to $1,000 in 1983 dollars. That's approximately 10 times the speed, 20 times the memory, and 1,000 times the auxiliary disk storage all at less than half the price. The new LC520 with built-in CD-ROM drive and color monitor has captured 75% of new Apple sales to schools in the 1993-94 school year.

Andrew Rappaport of the Technology Research Group has predicted that "by 1999 a powerful workstation performing 15 million instructions per second (MIPS) and commanding 16 megabytes of random access memory will sell for around $350" (Gilder, 1991).

Since Time Magazine gave the computer its Man of the Year Award in 1983, tremendous advances have taken place in computer and communications technologies. By the year 2000, high-bandwidth fiber optic networks will be ubiquitous and microcomputer performance will be equivalent to current supercomputers. New applications will arise throughout the decade, first applied in the business sector, then in schools.

The rapid pace of technological change is evidenced by the changes in processing power, storage capacity, and communication bandwidth as indexes:

- *Processing power* -- In the early 1980s, computers had 8-bit processors, 64K memory, and displayed in monochrome. By 1993, standard computers used 16- and 32-bit processors, 4 to 8 megabytes of memory, and displayed in high-resolution color -- making effective graphical user interfaces possible.
- *Storage* -- In the early 1980s, computers used 5-1/4" floppies storing 143K bytes, or the equivalent of 30 pages of text. In 1993, standard units have 40- to 80-megabytes (or more) hard drives, floppy drives storing 1.4 megabytes on a disk (10 times the early 1980 standard), and CD-ROM drives storing 550 megabytes, or 3,300 times the early 1980 storage.

- *Bandwidth in the public switched network (telephone) and in the Internet* -- Digital telephone networks at 64K bits per second (bps) were introduced in the early 1980s and by 1993 formed the basis of long-distance service. The Internet backbone ran at 1.5 Mbps in the late 1980s and will increase to 155 Mbps and 622 Mbps during the decade and reach 1 billion bits per second (1 Gbps) -- the gigabit network -- by the end of the decade (U.S. Congress, Office of Technology Assessment, 1993).

In the early 1980s, schools had a small amount of equipment, mostly state-of-the-art. Today, they have a lot of equipment, much outdated, and a small amount that is state-of-the-art.

Data from Market Data Retrieval in 1993 reports the school building penetration of the following technologies: Cable -- 76% of schools; Satellite - -17%; Modems - -64%; ILS -- 20%; LAN - -49%; CD-ROM -- 45%; Videodisc -- 41%; and Distance Learning -- 11% (Ednet, 1993). The problem with this data is that it tells only if the school has a particular technology, but not how much of it. It's equivalent to reporting that all 50 states have telecommunications networks for education. Penetration does not tell us anything about the level of intensity or the level of application.

In fact, the technological infrastructure for K-12 education is minuscule and most of the current school equipment will have to be replaced and re-purposed. For example, Quality Education Data reports that in the 1992-93 school year, less than 30% of school computers used a graphical user interface (GUI); 45% of current school computers are Apple IIEs and IIGs.

The next decade will see schools assimilating and implementing the great technological strides of the past decade as well as the continuing rapid changes in new technologies throughout the 1990s.

10.1 Telecommunications

Computer-based telecommunications is exploding in America. Commercial services such as Prodigy, CompuServe and America Online are nearing commercial viability, enhanced by the wide-area distributed network, the Internet, which allows for intercommunication among campuses, research organizations, companies and schools throughout the world.

Today schools can use computer-based telecommunications to participate in the International Arctic Project, the Global Lab, the National Geographic Kids Network, the AT&T Learning Network, and many others. By using computer-based telecommunications and accessing the resources and tools of the Internet, students and teachers in 21st century schools will be able to access information, communicate via electronic mail with each other and with mentors, engage in professional collaboration and student collaborative project work and communicate with scientists like Arctic explorer Will Steger on electronic field trips.

Internet nodes now exist in 600 colleges and universities in the US and throughout the world and in 1,000 US high schools. The Internet is doubling every year, according to Mike Roberts, executive director of EDUCOM, the higher education computer consortium. Roberts says that the Internet is "adding 1000 nodes a day. It would take 100 days to do all of K-12 in the United States" (Roberts, 1993). Roberts' enthusiasm notwithstanding, establishing an Internet node costs $37,000 including the leased line, an investment that has value for companies, universities and schools with critical mass, that is with a large number of users on a local-area network.

The National Science Foundation is financing testbeds for gigabit networks as part of the National Research and Education Network (NREN). But private investment from telephone and cable companies is swamping government investment and laying the foundation for the National Information Infrastructure or NII. Many people in Washington now openly talk of the International Information Infrastructure (III).

What has made this possible are dramatic developments in the digitization of telecommunications, according to Bob Lucky, vice president of applied research at Bell Communications Research (Bellcore). The first fiber optic system was set up in 1981. In the early 1990s Integrated Services Digital Network (ISDN), was finally available and also SONET and Asynchronous Transfer Mode (ATM) – new transmission standards and technologies for fast-packet switching. "The issue now," says Lucky, "is to build the local loop and access, or 'fiber to the curb'" (Lucky, 1993).

The challenge in telecommunications is to have sufficient bandwidth to process voice, data, images and video in a reasonable time. Images, for example, require 96 million bits of information. Even on a fast 64K bps telephone line, that takes 25 minutes. On a gigabit network, that would be reduced to 1/10 of a second. Similarly, HDTV requires 1.5 gbps, but with compression techniques it can be reduced fifty-fold to 30 Mbps (US Congress, Office of Technology Assessment, 1993).

ISDN can be an effective intermediate step on the way to a full fiber network. ISDN is 10 times as fast as the fastest modem and uses two 64K bit channels plus one auxiliary 16-bit channel for simultaneous transmission of voice and data. Robert Metcalfe, publisher of *Infoworld*, recently arranged a connection from his home in Woodside, CA, to his office and to the Internet through a phone line with ISDN equipment. "I'm bathing in bandwidth," says Metcalfe, "and I'm only paying 27 bucks a month to get it" (Markoff, 1993).

10.2 Multi-media and Optical Imaging

The premier edition of the Videodisc Compendium for Education and Training in 1988 listed more than 400 titles produced by 61 companies. The fifth edition, in 1993, listed over 2200 laserdiscs and compact disks (CDs), produced by 240 companies, or 600 more titles than in 1992 (Videodisc Compendium for Education and Training, 1993). CDs in education grew by 160% this year, with new products including multi-media encyclopedias, electronic atlases, newspapers and scores of image collections for educational use.

Videodiscs, which use analog video, hold either 54,000 still images or 30 minutes of full motion video. CDs hold 550 megabytes of digital information. CDs can do direct digital playback of images and video using software compression techniques to create digitized motion video. The software used to display full motion video, Quicktime for Macintosh and IBM PhotoMotion, was released in early 1992.

There were 75,000 CD-ROM drives in US schools in 1991. That's only 2.5% of the 3 million microcomputers in US schools. But today, CD-ROM based multi-media computers are emerging as a standard package. This latest generation of microcomputers, equipped with built-in CD-ROM players that essentially create a multi-media work station, will likely spurn the mass production of CD-ROM educational software.

Students in leading-edge schools today create multi-media documents with text, graphics, images and video as project reports that are published and presented. In some schools, teachers and students even make their own videodiscs and CD-ROMs. Some examples:

- Students at Kendom Elementary School in Lansing, Michigan, developed an interactive videodisc almanac with pictures and video clips of the school and the community and a hypercard front end with stories of their families and community (Pearlman, 1991).
- Teachers in Mahnomen, Minnesota, in partnership with the Ojibwe Native American Tribe, created an interactive CD-ROM on Ojibwe history and culture. For $4,500, the disk was mastered and 1,500 CD-ROM copies produced (Stearns, 1993).

Another explosion is about to occur with the increased availability and recognized usefulness of laserdiscs and CD-ROM technology products. The notion of developing an interdisciplinary approach to learning that cuts across all curricular areas is already being realized in classrooms that have access to these emerging technologies. As has been the trend with computer hardware, laserdiscs and CDs will decrease in price and increase in production. Students and teachers equipped with these powerful resource tools will become empowered to develop their own knowledge constructs through individual and group learning activities.

10.3 Distance Learning

According to the US Department of Education, Distance Learning is now used in 6000 schools for 20,000 elementary and 20,000 high school students. The TI-IN network, transmitting video via satellite from Texas, reaches 1,100 schools in 40 states (Bruder, 1991). The Massachusetts Corporation for Educational Telecommunications (MCET) delivers curriculum modules that support teaching to 37 states via satellite, PictureTel, videodisc and videotape.

Satellite delivery usually supports one-way video, while two-way audio is provided through a phone line. Fiber supports two-way video and two-way audio. New satellites using VSATs (very small aperture terminals) allow for one-way video and two-way voice, data, and fax transmission. Hughes Corporation's Galaxy Classroom uses this technology to provide innovative interactive television programming, with a focus on hands-on science curriculum, to 39 urban elementary schools across the nation. And PBS, in partnership with AT&T, will soon launch the Telestar 401 satellite, which uses VSATs, "as the nation's largest telecommunication highway for educational services" (Industry News, 1993). Telestar 401 will use digital video compression to increase dramatically the number of channels available through the satellite.

Advances in digital compression and in high-bandwidth networks throughout the 1990s will lead to interactive video distribution over cable, fiber and ISDN lines. Mind Extension University (MEU), which already delivers courses via cable, shows the potential for a number of public and private educational providers to offer informal and formal educational course and mini-courses. The future 500-channel cable networks, now on the horizon with the recent merger of Bell Atlantic and TeleCommunications Inc., will be one of the major delivery systems for distance learning.

10.4 Voice, Video, and Data Communications Networks

One of the eleven winning New American Schools design teams, the Massachusetts-based Co-NECT School from Bolt Beranek and Newman in Cambridge, is implementing its design at the ALL School in Worcester, MA. The team envisions the network design with six important capabilities -- universal access to technology for students and teachers, a local-area network for all computers at the school; connections with the home for home-school communication; connection with the Internet; connections of teachers for communication of professional information and television connections for communication of visual information (The Co-NECT School, 1992).

Though Market Data Retrieval reports that 49% of school buildings have LANs, most of these are relegated to a single lab or administrative area. Few schools have the schoolwide computer and video distribution networks envisioned in the Co-NECT design. There are exceptions, like Penn-Harris Madison High School in Osceola, Indiana, the Shoreline (Washington) School District, or Revere's Garfield Community Magnet School and the new Wareham High School in Massachusetts.

Schools will need Internet, cable and satellite connections, and internal voice, data and video distribution -- all of which requires significant investment. Unfortunately, too many schools, over 10,000 in the US, have settled for contracts with Chris Whittle's Channel One news program whereby the school gets a fixed satellite dish, receiving equipment, and 19-inch monitors in every room. It is a kind of "poor man's" video distribution network, having only the ability to send out two signals to classrooms and only receive from one satellite.

Building the home-school connection in America's communities will involve partnerships between the phone companies, cable companies, schools and the state to plan the local infrastructure.

10.5 Future Developments

Were technological advances to stop cold in 1993, America's schools would still have an enormous job ahead of them to integrate and implement the technological developments of the past decade. But future developments, bringing a convergence of computers and communications, will offer schools a great opportunity through vastly increased power, lower costs and the growing local communications infrastructure to make school technology investment pay off for students and communities.

With critical mass, telecomputers and high-bandwidth communications, schools will become more productive and efficient, and students will gain the skills and culture to be productive workers and citizens in the global economy of the 21st century.

George Gilder's vision applies to students of these 21st century schools -- "In essence, telecomputers will harness the full imaginative and sensory faculties that allow people to be most intuitive and creative. People will be able to talk face-to-face, travel in imagination around the globe; they will be able to show, not just tell. They will be able to call up audiovisual illustrations, transmit dynamic pictures, navigate through architectural designs and databases like pilots" (Gilder, 1991).

11. ENVISIONING THE FUTURE: AMERICA'S 21ST CENTURY SCHOOLS

"We are moving very rapidly in all forms of production and services to a knowledge-based economy in which what you earn depends on what you can learn. Not only what you know today, but what you are capable of learning tomorrow."

- Bill Clinton, May 1993

As education moves from a teacher-directed approach to a student-directed model, the expanded learning environments of the '90s will become the mainstay of the "virtual curriculum" of the 21st century. Full scale implementation of these teaching and learning models nationwide will provide the foundation for a stronger, more effective educational system. In envisioning the future for America's schools in the 21st century, the change will be dramatic. Our public education system of 1993 consists primarily of:

- schools that provide instruction approximately 180 days a year for about 8 hours per day
- students of similar age who spend the majority of their instructional time within the school building with limited access to resources beyond their classroom or school boundary
- instruction which assumes for the most part that learning is a function of teaching, emphasizing formal classroom instruction and teacher control of learning
- classrooms of students ranging from ages three-to-twenty-one, grouped according to age and instructional level (although recent education reforms have embraced heterogeneous grouping, ungraded primary schools and inclusionary education for special education populations)
- segregated efforts of community services (health, welfare, counseling, childcare, adultcare), all of which affect the well-being of school-aged children and their families
- limited sharing of information, resources and expertise with business and industry in the community

In contrast, envision education in America during the next century.

In the year 2000, the public education system provides:

- community education resource centers open year-round, approximately twelve-to-fifteen hours per day
- self-directed, activity-based learning that allows students of all ages, two-to-ninety-two, to learn and collaborate together
- an environment that fosters interaction among all participants
- learning organizations that are flexible, adaptive and embrace change
- collaboration with other institutions to multiply the effectiveness of services
- numerous value-added services to the community-at-large through community service projects
- expanded learning environments for student exposure to real-world issues and resolutions

In the year 2000, students:

- have a unique educational plan to achieve the student's individual social and academic potential
- master core concepts in the basic academic subjects and develop the full range of thinking skills, creative capacities and attitudes that help students adapt to an ever-changing world
- responsibly exercise their personal, political and economic freedom
- are prepared for the next stage in their education/occupation and have a foundation for lifelong learning

In the year 2000, the school learning environment:

- is flexible in terms of time, place, pace and learning style
- measures success in terms of student performance rather than clock hours
- extends to offices, factories, out-of-doors, homes, as well as information-rich school rooms
- provides access to a variety of resources and teaching strategies that fit students' diverse learning styles

In the year 2000, the teachers:

- are valued by students, parents and the general society
- oversee the learning process, facilitate classes and prescribe activities for individual students
- assess student need, diagnose problems, design instructional strategies and evaluate student performance
- team with colleagues in other subject matters to meet the diverse needs of their students
- employ state-of-the-art technology in their task of directing learning

In the year 2000, the curriculum:

- allows for each student to pursue personal educational goals in addition to a common core of knowledge and skills
- consists of logically-sequenced, common curricular goals designed to enable all students to develop and demonstrate competence in reading, written and oral language skills, math, science, social studies and the arts
- recognizes and provides opportunities for the development of several kinds of intelligence
- provides relevancy so that students are able to apply their knowledge to on-the-job and real-life experiences

In the year 2000, state-of-the-art technology:

- enhances student learning and assists staff in directing instruction and managing schools
- links to a wide range of applications that provide drill for individual learners, give teachers and students access to information data banks, and manage instruction for certain segments of the curriculum
- paces instruction according to student needs, at a generally convenient time and location and in a format best-suited to his/her learning style

- connects schools with each other and with other agencies in communities across the state, the country and the world
- encourages and supports collaborative learning and work experiences for all learners
- approaches equity by providing all students with access to rich and varied learning environments
- tracks individual student performance in a central data base

In the year 2000, "school" is the most inviting place in America's communities offering a caring, considerate environment free from insult, discriminatory attitudes and malice. A sense of community is synthesized from the diversity of the student population, making "school" the focus of student and community. The facility belongs to the community and is available for alternative uses throughout the year. Likewise, students receive instruction in business-owned facilities, community agencies, vocational-technical schools, community colleges and universities, as well as at home.

School budgets of the 1990s have been a constant funding battleground within communities around the nation. America's public education centers of the 21st century will garner broad-based support from the community-at-large by providing lifelong learning opportunities to all community members and fostering interagency collaboration among community service providers.

APPENDIX A

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